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- Infection Prevention and Control Practices in the Deployed Military Field Hospital
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The Journal of the Australasian Military Medicine Association

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Cover Photo: Ambulances come in many shapes and sizes *by Murray Hayes*

# Journal of Military and Veterans' Health



# Australasian Military Medicine Association



## 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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227 Collins Street Hobart Tas 7000 Australia
Ph: +61 3 62347844
Email: editorial@jmvh.org

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# Editorial

I hope this issue will provide you all with some further reading material to get you through the frustrating COVID19 lockdown. It has been a very challenging time for all in our community and added a layer of complexity to our defence force members and supporters.

This second issue for 2020 provides a potpourri of articles, including several international contributors; demonstrating the effect of heat exposure and previous experience on soldier's performance; a prevalence study on urological cancers in Homeland war veterans in Croatia; and an article from Turkey outlining the effect of depression on a reproductive and sexual health program in male soldiers.

Skipp et al. offer an integrative review of a deployed military field hospital with regards to infection prevention and Watt and Kehoe provide adjunct activities to improve veteran's mental health.

A regular contributor, CMDR Neil Westphalen, offers us an article outlining the military medical capabilities of the ADF and also provides us with a further contribution in his Navy medical history theme, taking us back to Ancient Egypt and Greece to help us reflect on the development of medicine over the ages. In a similar vein, Dennis Shanks outlines the mortality secondary to measles in armies of the 20th century.

I would like to conclude this editorial by offering a huge vote of thanks to three retiring editorial board members who between them have devoted many years of service to this journal, offering sage counsel on the many journal articles submitted to the journal for publication.

Colonel Darryl Tong, oral and faciomaxillary surgeon with the New Zealand Defence Force, is Professor and Head of the department of oral diagnostic and surgical sciences at the University of Otago. His particular interest and PhD topics were maxillofacial trauma and ballistic injuries in war from an integrated historical and surgical viewpoint. He served in Afghanistan in 2009 and in a field hospital for the Christchurch earthquake tragedy.

Dr Tyler Smith received his BS in mathematics and statistics from California State University and his PhD at UC San Diego. He is a statistical epidemiologist and professor at the National University. We have benefited from his expertise in military and population health analytics, and PTSD and suicide in the military and health outcomes.

Dr Benjamin Mackie is an army reserve nursing officer and a lecturer in nursing at the University of Sunshine Coast, achieving his PhD at Griffiths University. He is a Fellow of the Australasian College of Critical Care Nurses (FACCCN) and we have benefited greatly from his interest in hospital disaster preparedness and nursing critical care.

We wish them all well for their future academic and military careers and hope we can continue to reach out for their expertise for future articles requiring their reviewing input.

**Associate Professor Martin Richardson**
**Commander RAN**
**Deputy Editor**

# Loaded March and FORCE Combat™ Performance: Effects of Heat Exposure and Previous Experience

*H Tingelstad, T Reilly, B Kehoe, E Verdon, K Semeniuk, F Haman*

## Abstract

**Purpose:** This study investigated the effects of heat exposure and previous experience on thermoregulatory and cardiovascular responses to performing a loaded march in the HEAT and on FORCE Combat™ circuit performance.

**Methods:** Ten civilians (inexperienced) and 10 infantry reservists (experienced) performed a 60 min loaded march (~35kg), in NORMAL (21±0.2°C) and HEAT (30±0.2°C) conditions and the FORCE Combat™ military physical performance evaluation. Participant groups were matched for morphology and physiological capacity.

**Results:** Out of the 10 experienced participants that participated in the loaded march in HEAT, 9 completed the full 60 min but only 5 of 10 inexperienced participants were able to do the same. Performing a loaded march in the HEAT caused a state of uncompensable heat stress (continuous increase in core temperature) for both the inexperienced and experienced participants. Heart rate (134±12vs143±9bpm,p=0.027), rate of perceived exertion (13±1vs10±1,p≤0.001) and thermal comfort (1.9±0.5vs2.4±0.4,p=0.011) were lower in the experienced compared to the inexperienced group during the loaded march in HEAT. The FORCE Combat™ completion times were higher in HEAT compared to NORMAL, but lower in experienced participants in both conditions (p≥0.05).

**Conclusion:** Both heat exposure and previous experience had an effect on cardiovascular, thermal and subjective measures during the loaded march and on completion time of the FORCE Combat™ circuit.

## Introduction

It is well established that exercise in hot and humid environments has detrimental effects on performance due to the impact of hyperthermia, elevated cardiovascular stress and dehydration.[1,2] While these effects can impact the outcome in sports and athletic events, consequences during military operations may result in injury and possible loss of life. In this context, modern infantry soldiers are required to operate in any climate; carrying food, water and equipment, while wearing military personal protective equipment (PPE), in the form of helmet and ballistic plating. While wearing PPE is crucial to prevent life-threatening injuries, it remains energy costly,[3] reduces evaporative cooling and thus, increases the risk of hyperthermia by increased metabolic heat production and reduced heat loss.[4,5] This uncompensable heat stress, where maximal evaporative capacity is lower than required evaporative capacity, progressively increases core temperature and cardiovascular strain.[6, 7]

In 2017, the Canadian Army implemented a loaded march (5 km, wearing military PPE and carrying critical combat supplies weighing 35 kg) followed by a military-specific physical performance check (FORCE Combat™ circuit) for all of its members training for a land-based deployment. FORCE Combat™ is an evaluation designed to simulate the demands of dismounted or urban operations.[8] A large part of military training and performance testing is required to take place outside and an increasing number of military operations are taking place in extreme environmental conditions.[9] Although several studies have shown that performing moderate to high-intensity exercise in the heat while wearing PPE can induce uncompensable heat stress,[10,11] no previous studies have examined the cardiovascular and thermoregulatory response to performing a 5 km loaded march in a warm and humid environment while wearing military PPE.

Furthermore, several studies have suggested that previous task experience can have a beneficial effect on performance outcome and improve task solving tactics.[12,13] FORCE Combat™ is required to be performed by all members of the Canadian Army training for land-based deployment, ranging from soldiers in the field to truck drivers and desk clerks. However, the effects of heat exposure and previous experience on a loaded march and the FORCE Combat™ circuit performance has yet to be determined.

Consequently, the purpose of this study was to investigate the effects of heat exposure and previous experience on thermoregulatory and cardiovascular responses to performing a 60 min loaded march in the HEAT and on FORCE Combat™ circuit performance. More specifically, 10 inexperienced and 10 experienced men performed a loaded march at NORMAL temperature and in HEAT, where the effects of heat exposure and previous experience on thermoregulatory and cardiovascular responses and loaded march performance were assessed. Following the loaded march, an assessment of performance on the FORCE Combat™ circuit was performed, where the effects of heat exposure and previous experience on performance outcome were investigated. Based on results from previous studies,[12-15] it was hypothesised that performing a loaded march in the heat would have a greater negative effect on thermoregulatory and cardiovascular responses, thermal comfort and rate of perceived exertion (RPE), and FORCE Combat™ circuit performance in inexperienced participants compared to experienced participants.

## Methods

### Participants

A total of 20, 19–35 year-old healthy male participants were recruited. Ten participants were recruited from the civilian population with limited to no previous experience with a loaded march (INEXP), and 10 were reservist Canadian Armed Forces (CAF) members with extensive previous experience with loaded marching (EXP). Efforts were made to select participants in both groups to match for morphology (height, weight, body composition) and physiological capacity ($VO^2max$). Ethics approval for this study was received from the University of Ottawa Research Ethics Board, and the study was conducted following the guidelines of the Helsinki Declaration.

### Preliminary session

Participants recruited for this study were asked to undertake a preliminary session before any experimental data was collected. During the preliminary session, written consent was obtained from each participant and they also filled out the Par-Q & You health questionnaire[16] and the AHA/ACSM Health/Fitness Pre-participation Screening Questionnaire.[17] Height (Seca 217 Stadiometer, Seca, Hamburg, Germany) and weight (Sartorius Combics 2, Sartorius AG, Goettingen, Germany) were recorded, as well as an estimate of body composition using bioelectrical impedance analysis (InBody 520, InBody USA). The InBody 520 has previously been validated against the gold standard for body composition measurements, Dual Energy X-ray Absorptiometry.[18] Body surface area was estimated using the following equation developed by Dubois and Dubois.[19]

$$\text{BSA } (kg/m^2) = (height^{0.425} \text{ x } weight^{0.725}) \text{ x } 0.007184$$

Measurement of maximal oxygen consumption (VO2max) was also performed, using a metabolic cart system (FMS Field Metabolic System, Sable Systems International, Las Vegas, NV) during an incremental stepwise treadmill protocol (i.e., 1 min incremental stages until exhaustion).[20]

### Experimental procedures

Participants recruited for this study were asked to participate in three experimental sessions; an unloaded march at NORMAL temperature (21±0.7°C, 47±4% RH), a loaded march at NORMAL temperature (21.0±0.2°C, 49±3% RH) and a loaded march in the HEAT (30±0.2°C, 46±2% RH). Acclimation status of the participants was not assessed; however, all data collection was conducted between November and March where any heat acclimatisation due to weather should be negligible and none of the participants had occupations requiring them to work outside. For the loaded march, the participants wore military gear (including PPE) (25.1±0.5 kg) and a day pack, equal to a total external load of 35.1±0.5 kg. The unloaded march was used to familiarise participants with the equipment and procedures of the trial and to rule out any difference in thermal and cardiovascular responses between the participant groups. The unloaded march was performed on the initial experimental visit to the lab, whereas the order of the loaded march at NORMAL temperature and HEAT was randomised. All experimental sessions were separated by a minimum of four days to avoid any effects of fatigue. Participants were asked not to perform strenuous physical activity 24 hours prior to an experimental session, and abstain from alcohol and caffeine consumption for a minimum of 6 hours before testing. Participants were also encouraged to drink a minimum of 500 ml of water the night before and arrive in a fasted state. All experimental sessions took place in the morning between 7.00 and 11.00 am. Upon arrival, participants ingested a telemetric pill (Jonah™ Ingestible Core Temperature Capsule, Philips, NV, USA), used to measure core temperature ($T_{core}$). Nude weight and equipment weight were then recorded (Sartorius Combics 2, Sartorius AG, Goettingen, Germany) before participants were equipped with a heart rate (HR) monitor (Garmin Forerunner 310xt, Canton of Schaffhausen, Switzerland) and iButtons (Thermocron iBUTTONS® model DS1922H, Maxim Integrated, CA, USA) on 12 skin sites to measure skin temperature (Tskin). Following the equipment placement, participants donned the standardised military uniform with PPE and the day pack (total 35.1±0.5 kg). Participants then entered a climate-controlled chamber (3.3 m length x 2.3 m width x 2.3 m height), containing a precalibrated treadmill (True 850, True Fitness Technology, St. Louis, MO, USA). A facemask connected to a Field Metabolic System (FMS Field Metabolic System, Sable Systems International, Las Vegas, NV) was fitted on the participants, for the measurement of energy expenditure. Next, participants stood on the treadmill for a 10 min period of baseline data collection. Participants were then asked to walk on the treadmill at a speed of 5.17 km/h with a grade of 1%. Energy expenditure, HR and $T_{skin}$ were measured continuously, $T_{core}$ was recorded every 5 min, while thermal comfort (ASHRAE scale) and RPE was recorded every 10 min. The trial lasted 60 min or until participants' voluntary termination. Following the completion of the march, the participant exited the climate chamber, removed the day pack and within 5 min the FORCE Combat™ circuit was initiated. The FORCE Combat™ circuit is an evaluation designed to simulate the demands of urban operations.[8] The circuit consisted of four military physical performance tasks (20-meter rushes, sandbag lifts, loaded shuttle and a sandbag drag) performed continuously. The FORCE Combat™ circuit was performed outside the environmental chamber at room temperature (~22°C). Following the completion of the FORCE Combat™ circuit, a post-measurement of nude body and equipment weight was performed.

### Loaded march clothing and equipment

For the loaded march (NORMAL and HEAT0), in addition to cotton socks, cotton t-shirt, walking boots and uniform (approximately 3 kg), participants wore a fragmentation vest (7 kg), a tactical vest (10 kg), C7 Colt replica rubber rifle (3.7 kg), a helmet (1.6 kg) and a day pack (10 kg), for a total external load of ~35.3 kg.

### Skin, core and body temperature measurement

Wireless temperature sensors (Thermocron iBUTTONS® model DS1922H, Maxim Integrated, CA, USA) located on 12 sites: forehead, upper back, lower back, abdominal area, quadriceps, hamstrings, front calf, back calf, chest, biceps, forearm and hand were used to measure $T_{skin.}$ They were affixed to the skin using 3M Transpore tape (3M Canada, ON, Canada). The response time of the iButtons is 0:28±0:01 sec. Weighted mean skin temperature (Tskin) was calculated using the following skin site weightings: head 7%, hand 4%, upper back 9.5%, chest 9.5%, lower back 9.5%, biceps 9%, forearm 7%, abdominals 9.5%, quadriceps 9.5%, hamstring 9.5%, front calf 8.5% and back calf 7.5%.[21] Tcore was measured using a telemetric pill (Jonah™ Ingestible Core Temperature Capsule, Philips, NV, USA), and the signal from the telemetric pill was received, monitored and recorded on a Vital Sense Integrated Physiological Monitor (VitalSense, Philips, NV, USA). The thermal gradient between the core and periphery was calculated using the following equation.

$$\text{Thermal gradient} = T_{core} - T_{skin}$$

### Physiological strain index

The Physiological Strain Index was calculated using the equation developed by Moran et al.[22]

$$PSI = 5(T_{core}t - T_{core}0)x(39.5 - T_{core}0)-1 + 5(HRt - HR0)\ x(180 - HR0)-1$$

where $T_{core}0$ is resting core temperature, and $T_{core}t$ is the final core temperature. HR0 is resting heart rate and HRt is final heart rate.

### Heart rate, RPE and thermal comfort

Heart rate (HR) was measured using a Garmin Forerunner 310x (Garmin Ltd., Canton of Schaffhausen, Switzerland). The Garmin Forerunner 310x collected multiple samples per min, which were averaged and presented as the mean of a five min segment. The Borg Scale[23] was used to assess participants RPE and the 7-point ASHRAE scale[24] was used to determine the participants' perceived thermal comfort. Participants were asked to rate their RPE and thermal comfort level at the end of the baseline period and every 10 min during the march.

### FORCE Combat™ circuit

To measure the participants' military physical performance following the loaded march, total time to complete the FORCE Combat™ circuit was recorded. The FORCE Combat™ circuit consists of four military physical performance tasks: 20 m rushes with a drop to prone position every 10 m (4x), sandbag lifts (30x 20 kg sandbags lifted to a height of 1 m), an intermittent loaded shuttle carrying a 20 kg sandbag (participants perform 5x 40 m loaded shuttles, intermitted by a 40 m unloaded shuttle) and a 20 m sandbag drag (pull load equivalent to 330 N) performed continuously. A detailed description of the procedures of the FORCE Combat™ circuit are found elsewhere (www.forcecombat.ca). Total time (sec) to complete all four tasks were used as the performance measure. None of the participants in either group had previously been exposed to the specific evaluation used in this study.

### Statistical analysis

Due to previous pilot work on the FORCE Combat™ circuit showing an approximate 10% improvement from the first to second attempt, and no significant improvement from the second to third attempt[8], results recorded following the unloaded march were used only to confirm the absence of a difference in baseline marching data between experienced and inexperienced participants. Before performing any statistical analysis, all samples were tested for normal distribution. To compare changes over time and the effect of condition (NORMAL and HEAT), a two-way repeated measures ANOVA was used with an LSD post-hoc test to determine where significant differences occurred. An independent sample t-test was used to determine the effects of experience level. Differences in mean values for the total duration of the trial were compared for the effect of condition and experience level using a two-way ANOVA, with paired and independent sample t-test post-hoc tests to determine where significant differences occurred. A Bonferroni alpha correction was made for multiple t-test comparisons. Results were presented as mean±SD, and effect size was determined using Cohen's d and partial eta squared ($p\eta^2$). All statistical analyses were performed using SPSS 17.0 (IBM SPSS Statistics, Armonk, NY, USA).

## Results

Participant characteristics and loaded march results for INEXP and EXP are found in Table 1. Apart from the difference in previous loaded march

**Table 1: Participant characteristics for the INEXP and EXP group. BMI (Body Mass Index); BSA (Body Surface Area).**

| | INEXP | EXP | T-statistic |
|---|---|---|---|
| **Demographics** | | | |
| **n** | 10 | 10 | |
| **Age** | 26±3 | 23±5 | t(18)=1.378, p=0.185 |
| **Height (cm)** | 183.4±8.4 | 178.3±4.1 | t(18)=1.729, p=0.101 |
| **Body mass (kg)** | 80.9±9.4 | 78.6±13.2 | t(18)=0.495, p=0.651 |
| **BMI (kg*m$^2$)** | 24.2±3.2 | 24.7±3.4 | t(18)=-0.345, p=0.734 |
| **BSA (m$^2$)** | 2.03±0.13 | 1.96±0.16 | t(18)=0.720, p=0.481 |
| **Lean body mass (kg)** | 70.5±7.5 | 66.8±7.4 | t(18)=1.095, p=0.288 |
| **Body fat %** | 12.1±7.3 | 14.1±6.2 | t(18)=-0.649, p=0.525 |
| **VO2max (ml*min$^{-1}$*kg$^{-1}$)** | 49.1±4.3 | 49.2±4.9 | t(18)=-0.053, p=0.958 |
| **Loaded March** | | | |
| **Energy expenditure (kJ*min$^{-1}$*kg$^{-1}$)** | | | |
| **NORMAL** | 0.44±0.03 | 0.42±0.04 | t(18)=0.624, p=0.540 |
| **HEAT** | 0.45±0.04 | 0.45±0.04 | t(18)=0.240, p=0.813 |
| **Water loss (l)** | | | |
| **NORMAL** | 1.2±0.2 | 1.3±0.2 | t(18)=1.146, p=0.268 |
| **HEAT** | 1.4±0.3 | 1.6±0.3 | t(18)=1.523, p=0.146 |
| **%$VO_2$max** | | | |
| **NORMAL** | 42.2±4.9 | 40.4±1.7 | t(18)=1.102, p=0.285 |
| **HEAT** | 43.7±5.0 | 42.3±3.7 | t(18)=0.720, p=0.482 |
| **Load-to-body mass ratio (%)** | | | |
| **NORMAL** | 43.9±4.4 | 45.3±6.5 | t(18)=-0.549, p=0.590 |
| **HEAT** | 43.9±4.8 | 45.4±6.2 | t(18)=-0.554, p=0.587 |
| **Total work performed (kJ)** | | | |
| **NORMAL** | 58.7±4.9 | 57.8±6.9 | t(18)=0.324, p=0.750 |
| **HEAT** | 58.8±0.5 | 57.5±6.5 | t(18)=0.481, p=0.637 |

experience, there were no differences in participant characteristics between the two groups. There were also no differences in energy expenditure, water loss, loaded march intensity ($\%VO_2max$), load-to-body mass ratio and total work performed (kJ) between INEXP and EXP in either of the experimental conditions.

## Loaded march completion rates

All participants in both groups completed the unloaded march at NORMAL temperature. All 10 participants completed the loaded march at NORMAL temperature in EXP, and 9 of the 10 participants completed the loaded march in HEAT. The one EXP participant unable to complete the loaded march in HEAT asked to terminate the trial after 40 min due to gastric distress. In INEXP, 8 of the 10 participants were able to complete the loaded march at NORMAL temperature, and only 5 participants were able to complete the full 60 min of loaded march in the HEAT. One participant asked to stop the trial after 25 min in the NORMAL condition due to neck pain and migraine symptoms from the external load and he did not attempt the loaded march in the HEAT. The data from this participant was not included in the data analysis. Four other participants in INEXP requested to stop the trial before 60 min in the HEAT condition, due to exhaustion and intolerable discomfort.

Given the inability of several participants to continue the trial beyond 30 min in INEXP and 40 min in EXP, a statistical analysis comparing the effect of time and condition was performed only up until 30 min in INEXP and 40 min in EXP.

## Cardiovascular and thermoregulatory responses

The HR responses to a loaded march in a NORMAL and HEAT condition are found in Figure 1A and B, for INEXP and EXP respectively. A main effect of time ($F(8)=168.681$, $p<0.01$, $p\eta^2=0.960$) and condition ($F(1)=6.947$, $p=0.034$, $p\eta^2=0.498$) was observed in EXP for HR, as well as an interaction ($F(8)=6.204$, $p<0.01$, $p\eta^2=0.470$) between time and condition. In this group, a continuously steeper increase in HR over time was observed in the HEAT condition compared to NORMAL, from 20 to 40 min. A main effect of time ($F(6)=64.397$, $P<0.01$, $p\eta^2=0.902$) and condition ($F(1)=7.029$, $p=0.033$, $p\eta^2=0.501$) for HR was also observed in INEXP, with HR increasing over time and being higher in the HEAT compared to NORMAL. However, there was no interaction ($F(6)=3.631$, $p=0.072$, $p\eta^2=0.342$) between the two. Mean HR for the total duration of the trial (Figure 1C) was significantly higher in HEAT compared to NORMAL, in both the INEXP (8%) ($t(7)=-3.485$, $p=0.01$, $d=1.18$) and the EXP group (7%) ($t(7)=-4.964$, $p<0.01$, $d=1.13$).

Although there was no difference in HR between INEXP and EXP at any specific time point, mean HR was 4.4% ($t(14)=2.642$, $p=0.019$ $d=1.32$), and 5.6% ($t(14)=2.486$, $p=0.026$, $d=1.25$) higher in INEXP compared to EXP, in the NORMAL and HEAT conditions respectively (Figure 1C).

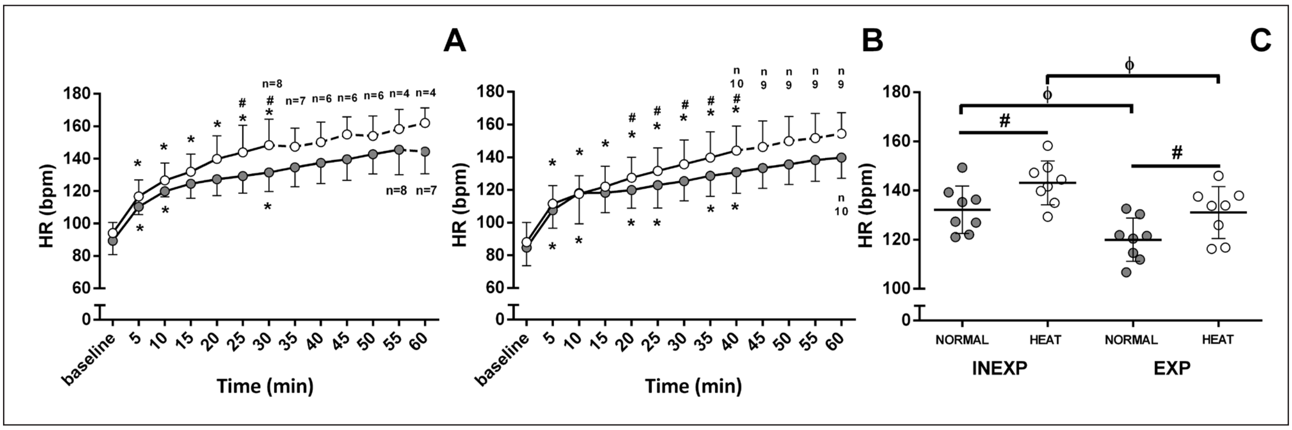


*Figure 1: Cardiovascular responses to performing a loaded march in NORMAL and HEAT condition for inexperienced (A) and experienced (B) participants and mean values (C). *significantly different from previous time point, # significant difference between NORMAL and HEAT, Φ significant difference between inexperienced and experienced. p≤0.05.*

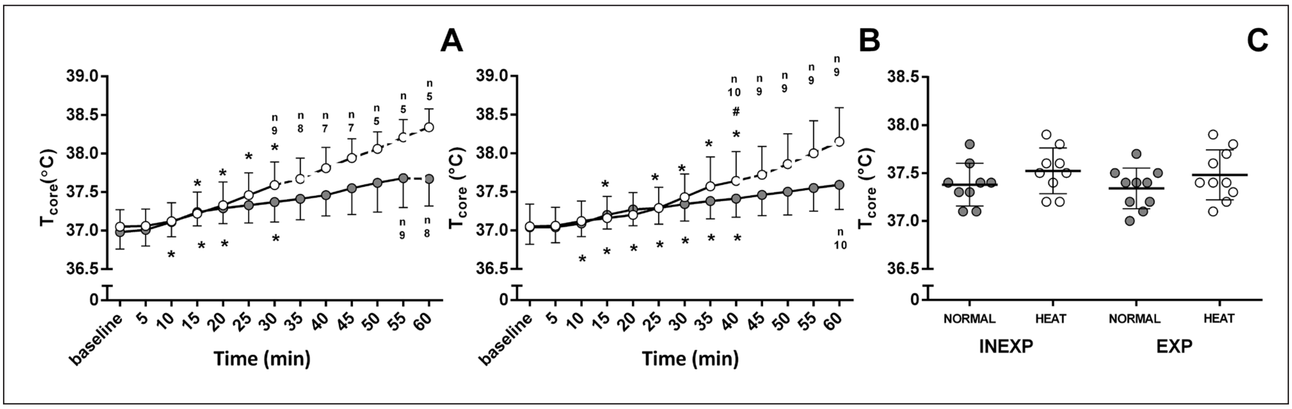


*Figure 2: Core temperature responses to performing a loaded march in NORMAL and HEAT condition for inexperienced (A) and experienced (B) participants and mean values (C). *significantly different from previous time point, # significant difference between NORMAL and HEAT, Φ significant difference between inexperienced and experienced. p≤0.05.*

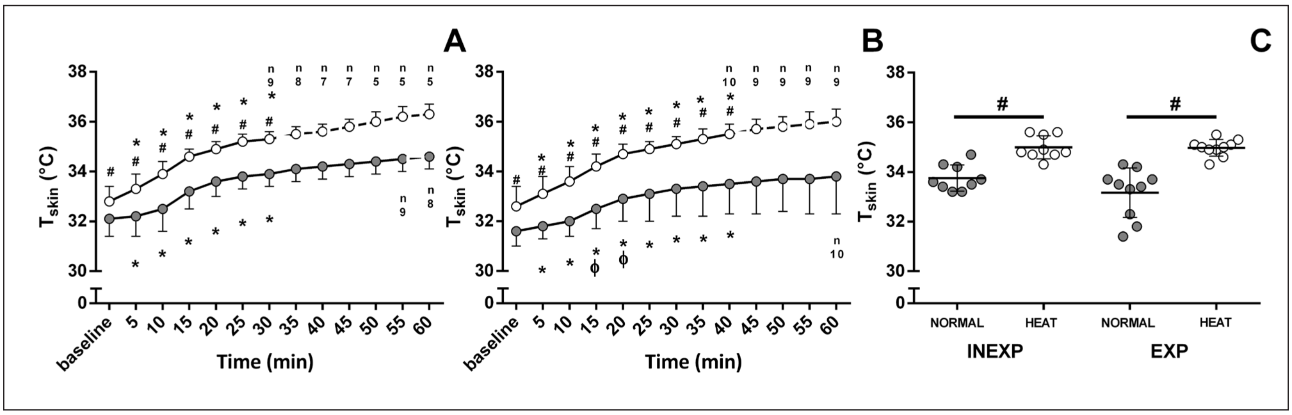


*Figure 3: Skin temperature responses to performing a loaded march in NORMAL and HEAT condition for inexperienced (A) and experienced (B) participants and mean values (C). *significantly different from previous time point, # significant difference between NORMAL and HEAT, Φ significant difference between inexperienced and experienced. p≤0.05.*

Change in $T_{core}$ over time is seen in Figure 2A and B, for INEXP and EXP respectively. A main effect of time ($F(6)=30.304$, $p<0.01$, $p\eta^2=0.791$ and $F(8)=45.012$, $p<0.01$, $p\eta2=0.833$ for INEXP and EXP respectively) and an interaction ($F(6)=4.763$, $p=0.042$, $p\eta^2=0.371$, and $F(8)=6.451$, $p<0.01$, $p\eta^2=0.418$ for INEXP and EXP respectively) between time and condition was observed in both INEXP and EXP but there was no main effect of condition. Increase in $T_{core}$ was significantly steeper in HEAT compared to NORMAL in both INEXP and EXP. Mean $T_{core}$ for the duration of the loaded march was not different between conditions (NORMAL and HEAT) in either INEXP ($t(8)=-1.886, p=0.096$), or EXP ($t(9)=-1.709$, $p=0.122$), and there was no effect of experience level on $T_{core}$ ($t(17)=0.379$, $p=0.709$ and $t(17)=0.366$, $p=0.719$, NORMAL and HEAT respectively) (Figure 2C).

A main effect of time ($F(6)=144.602$, $p<0.01$, $p\eta^2=0.948$ and $F(8)=61.494$, $p<0.01$, $p\eta^2=0.872$ for INEXP and EXP respectively) and condition ($F(1)=76.533$, $p<0.01$, $p\eta^2=0.905$ and $F(1)=46.998$, $p<0.01$, $p\eta^2=0.839$ for INEXP and EXP respectively) was observed for $T_{skin}$, in both INEXP and EXP (Figure 3A and B). There was also a significant interaction ($F(6)=15.387$, $p<0.01$, $p\eta^2=0.658$ and $F(8)=9.193$, $p<0.01$, $p\eta^2=0.505$) for INEXP and EXP respectively) between time and condition for $T_{skin}$, where a steeper increase in $T_{skin}$ was observed over time in the HEAT condition compared to NORMAL, for both INEXP and EXP.

$T_{skin}$ for the total duration of the loaded march was 3.7% (t(8)=-12.508, p<0.01, d=2.45) and 5.5% (t(8)=-6.434, p<0.01, d=2.47) higher in HEAT compared to NORMAL in INEXP and EXP respectively (Figure 3C). There was no effect of experience level on $T_{skin}$ in either the NORMAL (t(17)=1.607, p=0.127) or HEAT condition (t(17)=0.102, p=0.920).

The mean thermal gradient between periphery and core was significantly reduced during the loaded march in the HEAT compared to NORMAL (3.8±0.4 vs 2.8±0.5°C (t(8)=8.601, p<0.01, d=1.98) in INEXP and 4.3±0.9 vs 2.7±0.3°C in EXP (t(9)=5.220, p<0.01, d=2.18). At the end of the loaded march in HEAT the thermal gradient between core and periphery was reduced to 2.2±0.2°C and 2.2±0.3°C in INEXP and EXP respectively.

### Rate of perceived exertion and thermal comfort

Rate of perceived exertion (RPE) was not different between the NORMAL and HEAT condition in either INEXP (t(8)=-2.116, p=0.067), nor EXP (t(9)=-1.853, p=0.097) (Figure 4A). However, EXP reported a 26% lower RPE in the NORMAL condition (t(17)=2.785, p=0.013, d=1.24) and a 25% lower RPE in the HEAT condition (t(17)=4.371, p<0.01, d=2.), compared to INEXP.

Thermal comfort scores were significantly higher in the HEAT compared to the NORMAL condition, in both INEXP and EXP (34% (t(8)=-5.315, p<0.01,d=1.85) and 47% (t(9)=-5.459, p<0.01,d=1.54) respectively) (Figure 4B), meaning participants were less comfortable performing the loaded march in the HEAT compared to the NORMAL condition. Participants in EXP group also reported lower thermal comfort scores in both the NORMAL and HEAT condition, compared to INEXP (38% and 56% lower in NORMAL (t(17)=2.724, p=0.014, d=1.34) and HEAT (t(17)=2.849, p=0.011, d=1.34) respectively).

### Physiological Strain Index

Performing a loaded march in the NORMAL condition caused a moderate physiological strain for participants in both the INEXP and EXP group and when performing the loaded march in the HEAT, both groups reached the high physiological strain zone (Figure 5). Experience level had no effect on Physiological Strain Index, and there was no difference between INEXP and EXP in either condition (NORMAL t(16)=1.251, p=0.123; and HEAT t(16)=1.082, p=0.519).

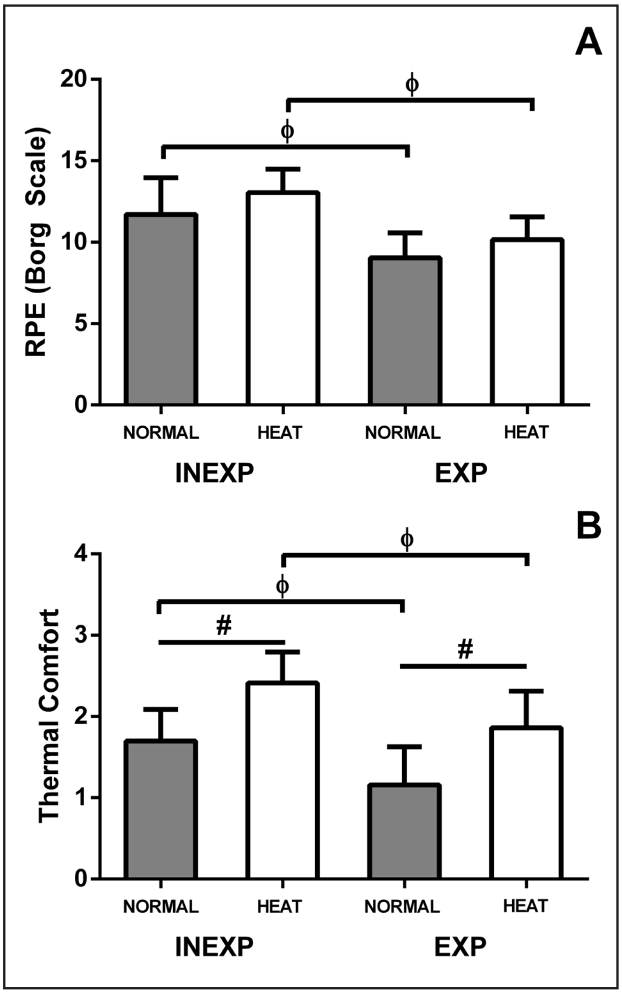


*Figure 4: Mean rate of perceived exertion (RPE) (A) and mean thermal comfort scores (B) for the inexperienced and experienced group during a loaded march in a NORMAL and HEAT condition. # significant difference between NORMAL and HEAT, Φ significant difference between INEXP and experienced group. p≤0.05.*

### FORCE Combat™ circuit performance

During the loaded march in the NORMAL condition, one of the EXP participants injured his shoulder, which severely affected his performance time on the FORCE Combat™ circuit. Therefore, his results were excluded from the analysis. Completion time on the FORCE Combat™ circuit was significantly affected by both condition and experience level (Figure 5). Completion time was significantly higher in the HEAT compared to the NORMAL condition, where INEXP increased completion time by 15% (88 sec) (t(8)=-3.816, p<0.01, d=0.73) and EXP increased completion time by 9% (43 sec) (t(8)=-3.670, p<0.01, d=0.73). There was also a difference in FORCE Combat™ circuit completion time between

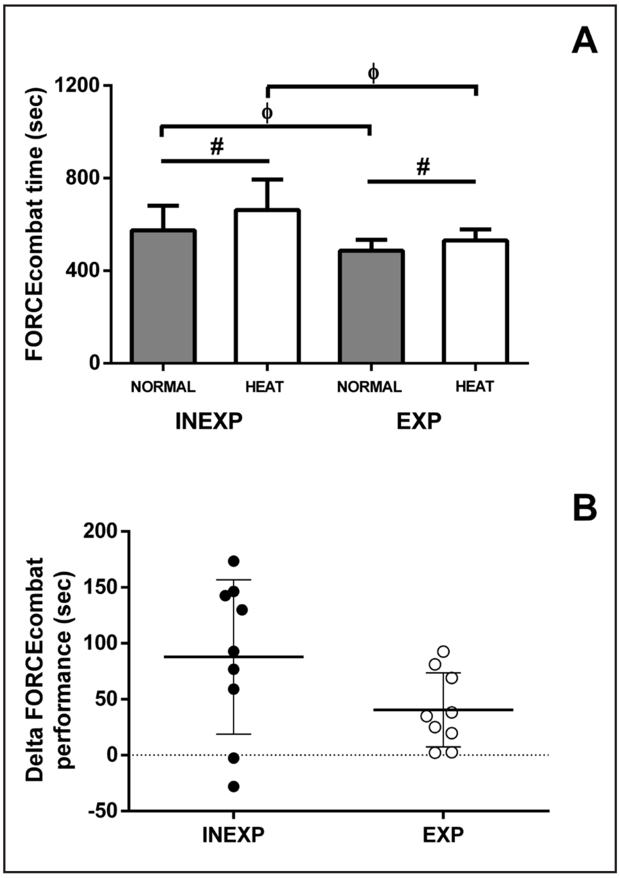


Figure 5: Calculated Physiological Strain Index at the end of an unloaded march and loaded march in NORMAL and HEAT for inexperienced and experienced participants. # significant difference between NORMAL and HEAT, Φ significant difference between INEXP and experienced group. p≤0.05."

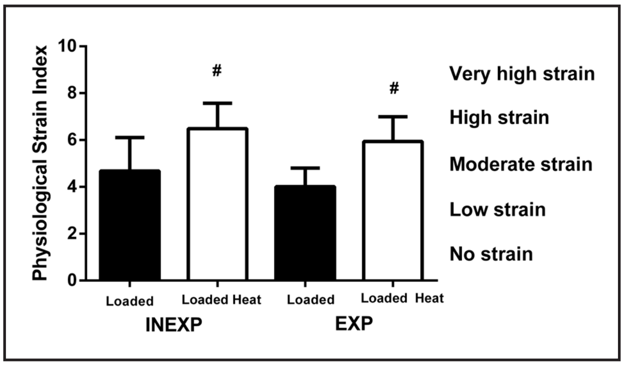


Figure 6: FORCE Combat™ completion times following a loaded march in a NORMAL and HEAT condition for inexperienced and experienced participants (A) and difference in completion time between NORMAL and HEAT condition (B). # significant difference between NORMAL and HEAT, Φ significant difference between inexperienced and experienced. p≤0.05.

EXP and INEXP, where EXP completed the FORCE Combat™ circuit significantly faster than INEXP, in both conditions (88 sec, or 10.7% faster in NORMAL ($t(16)=2.262$, $p=0.038$, $d=0.73$) and 132 sec, or 14.3% faster in the HEAT condition ($t(17)=2.946$, $p<0.01$, $d=1.27$) (Figure 6A). The difference in completion time between the NORMAL and HEAT condition is seen in Figure 6B. There was a trend towards a larger difference in completion time between the NORMAL and HEAT condition in the INEXP compared to EXP group; however, the difference was not significant ($t(16)=1.851$, $p=0.08$).

## Discussion

The purpose of this study was to investigate the effects of heat exposure and previous experience on thermoregulatory and cardiovascular responses to performing a 60 min loaded march and on FORCE Combat™ circuit performance. Results showed that heat exposure had a negative effect on completion rate, thermoregulatory, cardiovascular responses and FORCE Combat™ circuit performance. Performing a loaded march in HEAT (30±0.2°C, 46±2% RH) while wearing military PPE led to a state of uncompensable heat stress for participants in both the EXP and INEXP group. The two groups were matched for anthropometrics and $VO^2$max; however, the group with previous task experience (EXP) had a higher completion rate and lower HR, RPE and thermal comfort scores in the HEAT condition compared to the INEXP group. $T_{skin}$ and $T_{core}$ were not affected by experience level.

### Thermoregulatory and cardiovascular responses to loaded march in heat

PPE is designed to shield humans from external bodily harm. The properties of PPE cause a reduction in heat loss ability, due to the impermeable nature with which the equipment is constructed. Studies have reported a reduced heat loss ability in participants wearing different types of PPE, such as in soldiers wearing nuclear, biological and chemical protective ensembles,[7] firefighters,[25] and football players wearing pads and helmets.[11] The reduced heat loss can cause a state of uncompensable heat stress, depending on the intensity of the activity and environmental temperature.[6] Based on the continuous increase in HR, $T_{skin}$ and $T_{core}$ observed in this study, the results suggest that performing a loaded march in HEAT (30±0.2°C, 46±2%RH) while wearing military PPE exposes an individual to uncompensable heat stress. Uncompensable heat stress is also likely to be one of the main causes for several of the INEXP participants being unable to complete the loaded march in the

HEAT. The reduced ability for evaporative heat loss caused by the PPE would lead to an upregulation in skin blood flow to facilitate dry heat loss from the skin, which further exacerbates the cardiovascular strain of performing the loaded march. The increase in cardiovascular strain is believed to be the cause of participants inability to continue exercise, rather than a high $T_{core}$.[26, 27]

Core temperature did not reach critical levels in this trial (39–40°C threshold for increased risk of exertional heat stroke[28]). However, the PSI scores suggest that performing a loaded march in HEAT exposes participants to a severe physiological strain. When performing the loaded march at NORMAL temperature, participants only reached a moderate physiological strain (Figure 5). The 9°C increase in environmental temperature between the NORMAL and HEAT conditions, pushed participants in both the INEXP and the EXP group into the high physiological strain category. The thermal gradient between periphery and core was also significantly reduced during the loaded march in the heat causing a decline in the heat transfer ability from the core to the periphery. Based on these results it seems evident that performing a loaded march in the heat while wearing military PPE exposed participants to an uncompensable heat stress and a high physiological strain, which could have a significant effect on CAF members continued physiological capacity and operational readiness.

### The effect of previous experience

The effect of previous experience on performance outcome is a topic that has been given limited attention throughout the years, but a few studies have been conducted suggesting a beneficial effect of previous experience on performance and task solving ability.[12, 13] The results from this study support this idea. Even though the two participant groups were matched for morphology and physiological capacity, only five participants completed the loaded march in the HEAT in the INEXP group, compared to nine in the EXP group. The one participant unable to complete the loaded march in the HEAT in the EXP group was suffering from gastric distress, which is a common incident during high-intensity exercise in the heat.[29,30] Thermoregulatory responses ($T_{skin}$, and $T_{core}$) were not affected by experience level. However, participants in the EXP group had a significantly lower mean HR during the loaded march, in both the NORMAL and HEAT conditions, compared to the INEXP group. With no notable difference in anthropometry, and with participants working at a fixed workload, it is possible that the INEXP group had a higher sympathetic stimulation (stress response due to the stress of performing the loaded march task) leading to an increase in HR.[31] This response was reduced or absent in the EXP group due to their extensive experience with loaded marches. However, more research is required to confirm the mechanism behind the difference in HR between the INEXP and EXP groups.

Participants in the EXP group also reported significantly lower RPE and thermal comfort scores in both the NORMAL and HEAT conditions. However, there was no difference in aerobic capacity, body mass or body composition between the two groups. Based on these results, it seems that having previous loaded march experience led to a lower mean HR, RPE and thermal comfort scores during the loaded march, both in a NORMAL and HEAT condition. Although a limited number of studies have reported a beneficial effect of previous experience on task performance,[12,13] the cause of the positive effect on performance remains unclear. Micklewright and colleagues[12] suggest that previous task experience could have a beneficial effect on RPE, which was also observed in this study. However, more research is required to determine the specific mechanism causing the difference in performance between inexperienced and experienced participants.

### FORCE Combat™ circuit

For a large number of Canadian Army members, loaded marching is a common task and mode of transportation. Following the loaded march to the objective, soldiers need to maintain operational readiness and still be able to perform combat duties. Therefore, this study sought to determine how performing a loaded march in the HEAT compared to NORMAL temperature affects performance on the FORCE Combat™ circuit, performed immediately after the loaded march. The results showed that heat exposure led to an increase in completion times in both the INEXP and EXP group (Figure 6A). These findings are in accordance with previous publications showing that heat exposure can have a negative effect on exercise performance.[32, 33] It was also shown that participants in the EXP group had significantly lower completion times compared to participants in the INEXP group (Figure 6A). There was also a trend towards a larger increase in FORCE Combat™ completion between the NORMAL and HEAT condition in the INEXP group compared to the EXP group. There were no physiological or anthropometric differences that could explain the differences in completion time between the INEXP and EXP group; however, the participants in the EXP group had, apart from previous loaded march experience, also previous experience with urban operation exercises. None of the participants in either group had previously been exposed to this specific evaluation used in this study, yet the previous experience with similar tasks could potentially explain some of the difference in completion time. The results from this study confirmed the negative effect of heat exposure on physical performance and showed that previous experience had a positive effect on FORCE Combat™ circuit performance.

Performing a loaded march while wearing PPE is an essential task for soldiers serving in the armed forces, and since the march parameters and equipment cannot always be changed (shorter duration or lighter load), the results from this study suggest the requirement for an increased awareness of the negative effects of heat exposure on loaded march completion rates, cardiovascular and thermal responses, and military operational readiness. The conditions in which the loaded march and FORCE Combat™ circuit testing are performed (temperature and humidity) need to be monitored and measures like heat acclimation and hyper-hydration protocols could be required to maintain operational readiness. The outcomes of this research could also potentially be transferable to other military tasks and could have an implication on the focus on experience level and heat exposure when planning military exercises and operations. The results from this study clearly indicate the effects of both experience level and heat exposure on performance outcome. Future research should focus on expanding the participant pool and the demographics of the population (including females, older individuals and a wider range of body composition) to obtain more generalisable results.

## Conclusion

After assessing the effects of heat exposure and previous experience on a loaded march and FORCE Combat™ circuit performance, the results from this study showed that high environmental temperature and humidity had a negative effect on thermoregulatory and cardiovascular responses during a loaded march. The high environmental temperature also caused a state of uncompensable heat stress and reduced performance on the FORCE Combat™ circuit. On the other hand, previous experience had a beneficial effect on the ability to complete a loaded march in the HEAT and on FORCE Combat™ circuit performance.

## Acknowledgements

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## Conflict of Interest

The authors declare they have no competing interest and declare that they have no conflicts of interest to disclose. The results of the present study do not constitute endorsement by the America College of Sports Medicine.

*Corresponding Author: Hans Tingelstad,*
*hans.chr.tingelstad@gmail.com*
*Authors: H Tingelstad[1], T Reilly[1,2], B Kehoe[1], E Verdon[1], K Semeniuk[1], F Haman[1]*
*Author Affiliations:*
*1 University of Ottawa, Health Sciences- School of Human Kinetics*
*2 Canadian Forces Morale and Welfare Services, Human Performance Research and Development*

## References

1. Tatterson AJ, Hahn AG, Martini DT, et al. Effects of heat stress on physiological responses and exercise performance in elite cyclists. J Sci Med Sport. 2000;3(2):186–193.
2. Galloway SD, Maughan RJ. Effects of ambient temperature on the capacity to perform prolonged cycle exercise in man. Med Sci Sports Exerc. 1997;29(9):1240–1249.
3. Ricciardi R, Deuster PA, Talbot LA. Metabolic demands of body armor on physical performance in simulated conditions. Mil Med. 2008;173(9):817-824.
4. Caldwell JN, Engelen L, van der Henst C, et al. The interaction of body armor, low-intensity exercise and hot-humid conditions on physiological strain and cognitive function. Mil Med. 2011;176(5):488–493.
5. Havenith G, Bröde P, Hartog Ed, et al. Evaporative cooling: effective latent heat of evaporation in relation to evaporation distance from the skin. J Appl Physiol. 2013;114(6):778–785.

6. Sawka MN, Pandolf KB. Physical exercise in hot climates: physiology, performance and biomedical issues. Med Asp Harsh Enviro. 2001;1:87–133.
7. Cheung SS, McLellan TM, Tenaglia S. The thermophysiology of uncompensable heat stress. Physiological manipulations and individual characteristics. Sports Med. 2000;29(5):329–359.
8. Reilly T, PhD, Stockbrugger B, MSc, Saucier S, et al. Physiological demands of FORCEcombat: An Fitness Objective for the Canadian Army. Canad Inst Mili Vet Health Res For; 21–23 November; Vancouver, Canada. 2017.
9. Epstein Y, Druyan A, Heled Y. Heat injury prevention--a military perspective. J Strength Cond Res. 2012;26 Suppl 2:S82–86.
10. Montain SJ, Sawka MN, Cadarette BS, et al. Physiological tolerance to uncompensable heat stress: effects of exercise intensity, protective clothing and climate. J Appl Physiol. 1994;77(1):216–222.
11. Armstrong LE, Johnson EC, Casa DJ, et al. The American Football Uniform: Uncompensable Heat Stress and Hyperthermic Exhaustion. J Athl Train. 2010;45(2):117–127.
12. Micklewright D, Papadopoulou E, Swart J, et al. Previous experience influences pacing during 20 km time trial cycling. Br J Sports Med. 2010;44(13):952–960.
13. Seifert L, Wattebled L, L'Hermette M, et al. Skill transfer, affordances and dexterity in different climbing environments. Hum Mov Sci. 2013;32(6):1339–1352.
14. Nybo L, Rasmussen P, Sawka MN. Performance in the Heat—Physiological Factors of Importance for Hyperthermia-Induced Fatigue. Compr Physiol: John Wiley & Sons, Inc. 2011.
15. O'Hearn K, Tingelstad HC, Blondin D, et al. Heat exposure increases circulating fatty acids but not lipid oxidation at rest and during exercise. J Therm Biol. 2016;55:39–46.
16. American College of Sports Medicine. Physical Activity Readiness Questionaire (PAR-Q). 1997.
17. Balady GJ, Chaitman B, Driscoll D, et al. Recommendations for Cardiovascular Screening, Staffing, and Emergency Policies at Health/Fitness Facilities. Circulation. 1998;97(22):2283–2293.
18. Anderson LJ, Erceg DN, Schroeder ET. Utility of multifrequency bioelectrical impedance compared with dual-energy x-ray absorptiometry for assessment of total and regional body composition varies between men and women. Nutr Res. 2012;32(7):479–485.
19. Dubois D, Dubois EF. A formula to estimate the approximate surface area if height and weight be known. Arch Intern Med. 1916;17:863–871.
20. Balke B, Ware RW. An experimental study of physical fitness of Air Force personnel. U S Armed Forces Med J. 1959;10(6):675–688.
21. Hardy JD, Du Bois EF, Soderstrom GF. The Technic of Measuring Radiation and Convection: One Figure. J Nutr. 1938;15(5):461–475.
22. Moran DS, Shitzer A, Pandolf KB. A physiological strain index to evaluate heat stress.
23. Am J Physiol Regul, Integr Comp Physiol. 1998;275(1):R129–R134.
24. Borg GAV. Psychophysical bases of perceived exertion. Med Sci Sports Exerc.
25. 1982;14(5):377–381.
26. ASHRAE Asoh, refrigerating and air-conditioning engineers Handbook, ASHRAE Fundamentals. Inc: Atlanta, GA, USA. 2009.
27. Barr D, Gregson W, Reilly T. The thermal ergonomics of firefighting reviewed. Appl Ergon. 2010;41(1):161–172.
28. Périard JD, Cramer MN, Chapman PG, et al. Cardiovascular strain impairs prolonged self-paced exercise in the heat. Exp Physiol. 2011;96(2):134–144.
29. Sawka MN, Wenger CB, Pandolf KB. Thermoregulatory Responses to Acute Exercise- Heat Stress and Heat Acclimation. Compr Physiol: John Wiley & Sons, Inc. 2010.
30. Armstrong LE, Casa DJ, Millard-Stafford M, et al. Exertional heat illness during training and competition. Med Sci Sports Exerc. 2007;39(3):556–572.
31. van Nieuwenhoven MA, Vriens BE, Brummer RJ, et al. Effect of dehydration on gastrointestinal function at rest and during exercise in humans. Eur J Appl Physiol. 2000;83(6):578–584.

32. Neufer PD, Young AJ, Sawka MN. Gastric emptying during exercise: effects of heat stress and hypohydration. Eur J Appl Physiol Occup Physiol. 1989;58(4):433–439.

33. Kudielka BM, Schommer NC, Hellhammer DH, et al. Acute HPA axis responses, heart rate, and mood changes to psychosocial stress (TSST) in humans at different times of day. Psychoneuroendocrinology. 2004;29(8):983–992.

34. Ely MR, Cheuvront SN, Roberts WO, et al. Impact of weather on marathon-running performance. Med Sci Sports Exerc. 2007;39(3):487–493.

35. Gonzalez-Alonso J, Calbet JA. Reductions in systemic and skeletal muscle blood flow and oxygen delivery limit maximal aerobic capacity in humans. Circulation. 2003;107(6):82–-830.

# Warfare, Ships and Medicine in Ancient Egypt and Greece

*Commander N Westphalen*

## Introduction

A previous article described the prehistoric origins of weapons, ships and medicine. Although hominids began using weapons for hunting animals up to five million years ago, the earliest archaeological evidence of their use by *Homo sapiens* for warlike purposes (as opposed to other forms of interpersonal violence) is only dated to c11,000 BCE. This may indicate how the struggle to survive became rather less dire with the advent of farming and animal domestication from c12,000 BCE, and the ensuing increased differentiation of commodities within and between the first settlements that were considered worth trading and/or fighting for.[1]

These events initiated a cycle whereby increasing trade drove a need for larger and more efficient ships to transport merchandise, and for better weapons to defend or attack them; both of which in turn facilitated more trading opportunities. However, it was not until the 18th century that maritime medicine had developed sufficiently for its role as an enabler of this cycle to be recognised, thereby making possible the European settlement of Australia.[2]

This article describes, for better and for worse, the technical and other developments in warfare, ships and medicine in ancient Egypt and Greece from c4000 to c30 BCE.

## Ancient Egyptian and Greek Warfare

Many early settlements would have needed protection from external aggressors, who themselves required bases to operate from. The weapons to both these ends were made of wood and stone until the development of bronze alloy in c3500 BCE resulted in the first such weapons from c2000 BCE. These were displaced by weapons of tempered steel made from wrought iron from c900 BCE.[3,4]

Whatever fighting occurred between these early farms, hamlets, and villages was probably conducted by informally organised groups. The size and scope of their operations would have been limited by the supplies and social structures that sustained them, as well as the lack of reasons to fight beyond the immediate needs of their communities. Hence, it seems likely that much of the fighting during this period was largely ritualistic, with few combat casualties.[5,6]

However, by c4000 BCE the suitability of what is now modern Iraq for agriculture and trade between India and the rest of the Middle East led to the first towns and cities in what became ancient Sumeria. The next 2000 years saw the development of new weapons such as battle axes, composite bows, armour, chariots and cavalry, as well as innovations as to their use such as phalanx formations, rank hierarchies and headquarters staffs. These advances were made possible by societal developments that could sustain formed armies and provide them with the means and rationales to fight. The first such society was the Assyrian Empire, which waxed and waned at various times in modern Iraq, Turkey and Egypt from c1900 to 612 BCE.[7,8,9]

The bow remained ancient Egypt's weapon of choice throughout their military history, possibly because the hot climate prevented them and their opponents from wearing armour. Egyptians first began using them for fighting from c3000 BCE, at which time their arrowheads changed from stone to obsidian. Obsidian arrowheads was replaced by bronze around 2000 BCE, and then by domestically produced iron arrowheads from c1000 BCE.[10]

The first wheeled carts were developed in the Middle East in c3150 BCE, while the steppe-dwellers of modern Russia had domesticated horses for meat and milk (and later to ride) sometime before 2500 BCE. The latter combined these two elements to create the first horse-drawn chariots from c2000 BCE. These consisted of a light two-wheeled cart drawn by one or more horses, with a driver and a 'weaponeer' armed with javelins or bows. The Egyptians used chariots to race into positions where they could shower their opponents with arrows, and then withdraw before being counterattacked. The greater mobility of cavalry led to the abandonment of chariots by 400 CE.[11,12]

*Egyptian soldiers, Queen Hatshepsut's tomb, Deir El-Bahrim Egypt, c1493 BCE.[13] Note the battleaxes.*

*Egyptian chariot, c1400 BCE.[14] Note the driver and bowman 'weaponeer'.*


*Bronze Egyptian sickle sword or 'Khopesh', c1200 BCE.[15] Most Egyptian soldiers used bows, spears, axes or maces.*

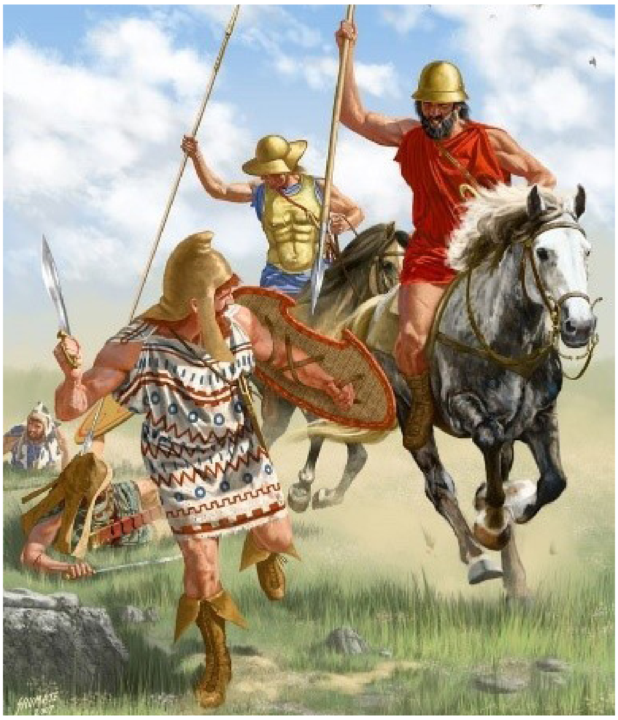
The Greek phalanx ('finger') infantry formation can be dated via the Egyptians to Sumerian times. It consisted of a close-packed formation of soldiers ('hoplites'), each protected by a helmet, breastplate, greaves (shin guards), and shield that each man interlocked with their neighbours, while armed with a sword and long thrusting spear.[16,17]

Tactics entailed each row of hoplites being pushed by the one behind through an opponent (assuming they stood their ground), in a highly bloody form of 'reverse crowd control'.[18] Their flanks were protected by unarmoured and hence more mobile infantry ('peltasts') armed with javelins, while cavalry were used to ride down defeated opponents.[19] Archers were used to break up opponents prior to attack by the phalanxes, and to defend against cavalry.[20]

The most important land battle in ancient Greek history was fought in 480 BCE at Thermopylae, a narrow pass between the Malian Gulf and Mount Kallidromo, in north-eastern Greece. About 7000 men from several Greek city-states held off up to 80,000 invading Persians for three days.[21]

*Greek hopites in action, c500-c300 BCE. [22] Note the spears, interlocked shields, helmets, breastplates and greaves.*

*Greek peltast (light infantryman), c500-c300 BCE.[23] Note the lightweight shield, javelins and lack of armour.*



Greek cavalry riding down defeated opponents, c320 BCE[24]

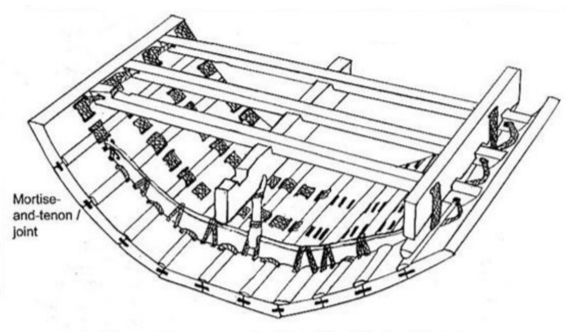
## Ancient Egyptian and Greek Ships

The previous article described how the first watercraft were limited by their small size and limited seaworthiness to inland rivers, lakes and estuaries. Yet the earliest evidence of Mediterranean seafaring (dated to 10,000-3000 BCE), are obsidian flakes found in mainland Greece from Melos, an island 50 nautical miles offshore.[25]

The first evidence of true seagoing ships is dated 2000-3000 BCE, from Egypt. They were built of papyrus reed until increasing trade with modern Israel and Syria led to the use of imported wood. These 'Byblos' ships used 'shell-first' construction, with mortise-and-tenon joints between planks jigsaw-fashion, which were secured with rope and made watertight with plant material. Ribs were added to form the hull, while the lack of a keel led to a large rope being strung from bow to stern above the deck as a 'hogging truss' for longitudinal strength. These ships used both sails and oars, to voyage as far as the east coast of Africa in c1400 BCE, and India 300 years later.[26,27,28]

The Egyptians also had the first Navy, which was used to rapidly move troops along the Nile. The first known sea battle occurred in 1278 BCE near the Nile delta, between a force led by the Egyptian pharaoh Ramesses II, and the 'Sea Peoples' whose origins remain unknown. This engagement, like many others until the 16th century CE, was fought with land troops.[29]

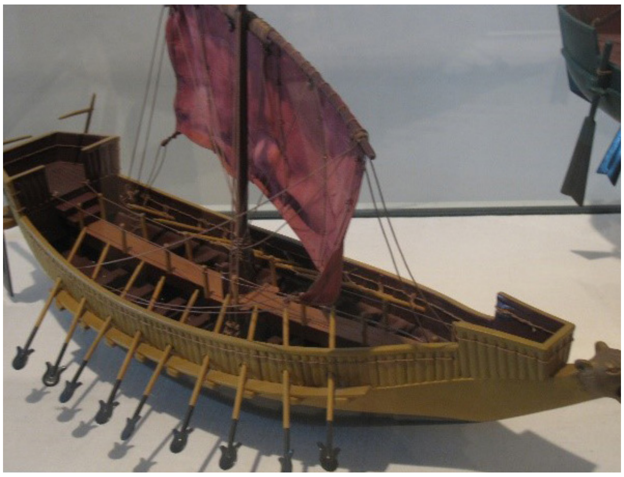
*Khufu ship, dated c2500 BCE, bow view [30]. She is 43.6m long, 5.9m beam, displaces 45 tons, and is one of the oldest, largest, and best-preserved vessels from antiquity. She was found in a pit at the Giza pyramid complex, disassembled into 1223 pieces but otherwise complete, in 1954. [31]*




*Construction technique, Khufu ship.[32] Note the small pieces of wood (tenons) that fit into opposing slots (mortises) between each plank, and how the joints between the latter are covered by battens. Also note the lack of a keel, the ribs used to add transverse strength, and how the whole structure is roped together.*

*Replica Egyptian seagoing 'Byblos' ship Min of the Desert, from c1500 BCE.[33] Note the sail, the fore-and-aft anti-hogging truss, and places for oars.*

*Rowing technique, Min of the Desert replica from c1500 BCE.*[34]



*Replica model Egyptian 'warship' from c1200 BCE.*[35] *Note it is essentially the same as near-contemporary Egyptian merchant ships.*

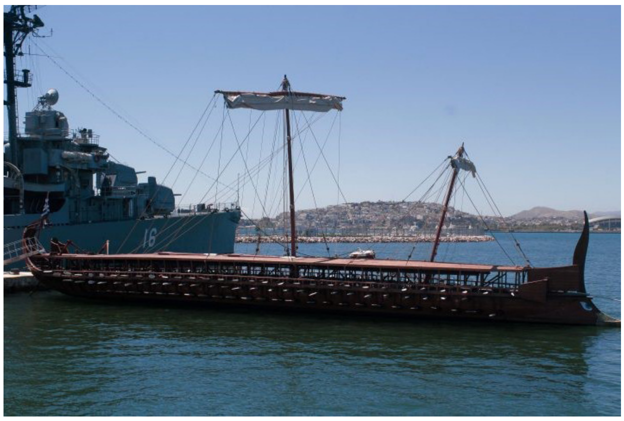
The first dedicated warships were built by the Greeks from c800 BCE. These used similar mortise-and-tenon joints as the Egyptians, but had a true keel for longitudinal strength, and were fastened with wooden dowels or 'treenails' rather than rope. As they had 50 rowers (25 each side) in a single row or 'bank', these ships were known as 'pentecontors'.[36,37]

Pentecontors and their successor galleys used oars during battle, after landing the masts and sails used to make extended passages.[38] Their speed and endurance under oars were restricted by their rowers' strength and stamina, while that under sail was constrained by their limited food and water stowage, as well as the inability to cook or even sleep at sea. As these ships therefore had to be drawn up on a convenient beach each night, and the latrine arrangements for the rowers in particular would have depended on coordinating how they were released from their oars, it seems likely that each evening included some highly unpleasant bilge-cleaning, with all the ensuing hygiene issues.

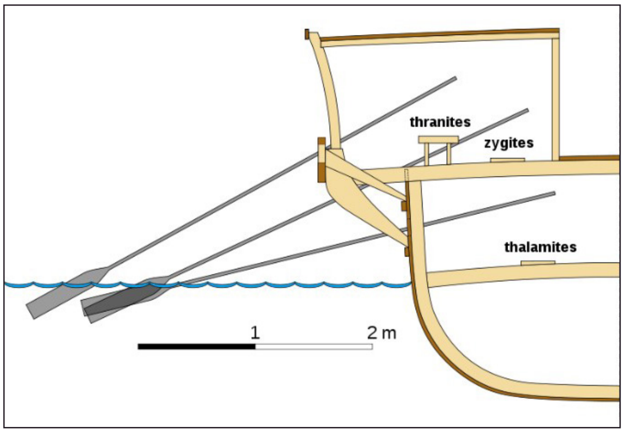
Pentecontor tactics entailed sweeping close inboard to smash their opponents' oars and injure the rowers, which made them vulnerable to then being sunk by ramming.[39] By 700 BCE, the need for additional power for more effective ramming led to double-(bireme) and triple-banked (trireme) ships with up to 180 rowers. As their inability to row and fight simultaneously meant the rowers' combat role was limited to fighting ashore, Greek triremes carried up to ten hoplites and four archers to shoot up their opponents.[40,41]

The most important sea battle of the era was fought within days of the Battle of Thermopylae, in the strait between Piraeus (near modern Athens) and the island of Salamis. The Greek historian Herodotus (484-425 BCE) describes how 400 triremes commanded by the Athenian general Thermistocles defeated 1200 ships under Ariabignes, brother of King Xerxes of Persia.[42]

*Replica Greek Pentecontor Argo from c800 BCE.*[43] *Note the rather petite ram bow and single bank of oars.*



*Replica Greek trireme Olympias from c700 BCE.*[44] *Note the more prominent ram bow with bronze beakhead, and oars banked in three vertical layers.*




*Greek trireme rower arrangement, c700 BCE.*[45] *Note the low freeboard resulting from the thalamite oar ports.*

*Greek trireme in action, 480 BCE.*[46] *Note the absence of the mast and sail, and the hoplites and archers on the upper deck. Also note the oblique ramming angle, which not only holes their opponents' hull, but also breaks more oars (thereby also injuring more rowers) compared to perpendicular 'T-boning'.*

## Ancient Egyptian and Greek Medicine

The previous article described how identifying surgical treatments for uncomplicated cuts, abrasions and limb fractures during the prehistoric period was probably fairly straightforward, but less so for medical conditions because of the inability to accurately diagnose them, or to match diagnos(e)s to the right doses of the right therapeutic agent(s). Whilst many medications therefore failed with respect to being actively therapeutic, discovering their relative *non*-toxicity meant they were unlikely to do much harm, while facilitating the emotional, social and spiritual support provided by caregivers. It seems likely that these agents became the basis of folklore-based treatments, which probably led to at least some modern complementary medicines.[47]

The cause of disease in ancient Egypt were ascribed to sin, or that the patient was under attack from a demon or ghost, or that a god wanted to teach them a lesson. Treatment therefore entailed driving away the ghost or demon, placating the god(s) who caused the illness, or invoking protection from a higher god as a preventative.[48]

The god of magic Heka was also a god of medicine, who carried a staff entwined with two serpents.[49] This symbol was passed on to the Greeks who associated it with their god of healing, Asclepius, which is still recognisable today as a symbol of the medical profession.[50] Other Egyptian healing deities included the warrior or lion goddess Sekhmet,[51] the scorpion goddess Serket,[52] the crocodile god Sobek,[53] and the lotus blossom god Nefertum.[54]

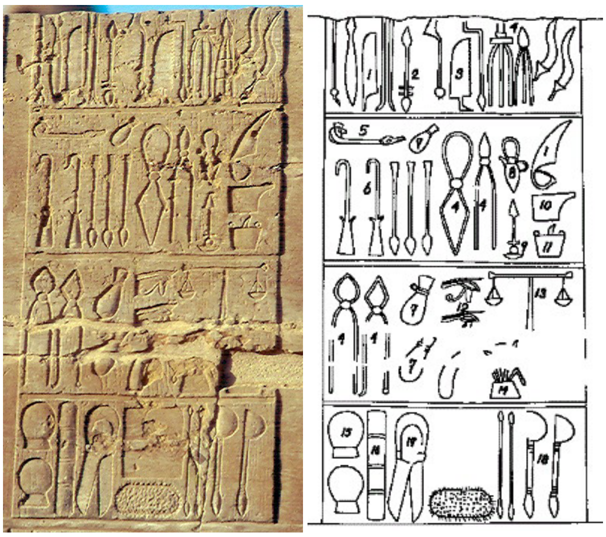
Hence, Egyptian doctors recited incantations with the use of amulets, offerings, aromas, tattoos, and statuary. Their incantations were recorded on papyrus scrolls that became the medical texts of the day. For example, the Demotic Magical Papyrus of London and Leiden (c300-200 BCE) is devoted entirely to magical spells and divination.[55]

At a less-spiritual level, the Edwin Smith Papyrus (c1600 BCE) is the oldest work on surgical techniques[56]. while the Hearst Medical Papyrus (c2000-1500 BCE) describes urinary tract infections and digestive problems.[57] The Kahun Gynaecological Papyrus (1820 BCE) deals with conception and pregnancy issues as well as contraception (noting that, rather unusually, ancient Egyptians had female as well as male doctors), as does the Berlin Medical Papyrus (c1570 – c1069 BCE), which includes the earliest known pregnancy tests.[58] The Ebers Papyrus (c1550 BCE) describes treatment for heart disease, diabetes, birth control, depression and cancer (for which it says there is no treatment).[59] The Chester Beatty Medical Papyrus (c1200 BCE) describes treatment for anorectal disease and – rather presciently 3200 years later – the use of cannabis for cancer patients.[60]

The Egyptians often performed surgical procedures, using flint and metal scalpels, dental pliers, bone saws, probes, catheters, artery and other forceps, speculae, lancets, sponges, scissors, phials, bandages, and scales for weighing the proper amount of raw materials to mix for medicines. Operations were frequently successful, as shown by mummies and other remains who survived amputations and even brain surgery. Prosthetic limbs, usually made of wood, have also been identified.[61]

Dental problems were common throughout ancient Egypt's history, possibly because of their diet of coarse bread and the inability to keep sand out of their food. The first dentist worldwide to be known by name is Hesyre (c2600 BCE), the Chief of Dentists and Physician to King Djoser.[62]

*Ebers Papyrus, c1550 BCE.[63] This page recounts a 'tumour against the god Xenus' and recommends 'do thou nothing there against'.*



*Left: Egyptian surgical instruments, c330-c30 BCE[64]*

*Right: Key – (1) knives; (2) drill; (3) saw; (4) forceps or pincers; (5) censer (incense or perfume burner); (6) hooks; (7) bags tied with string; (8, 10) beaked vessel; (11) vase with burning incense; (12) Horus eyes; (13) scales; (14) pot with flowers of Upper and Lower Egypt; (15) pot on pedestal; (16) graduated cubit or papyrus scroll without side knot (or a case holding reed scalpels); (17) shears; (18) spoons.[65]*

*Egyptian god of magic and medicine, Heka.[66] Note the snakes.*

*Prosthetic toe made of cartonnage (layers of of linen or papyrus covered with plaster, rather like papier-mâché), 1070-664 BCE[67]*

*Egyptian dental bridge, c2000 BCE.[68] Note the donor teeth, mandibular osteotomy (apparently unhealed, given the lack of remodelling), and gold wire.*

Although in practice they still never wholly separated the two, Greek medical practitioners began differentiating the material from the spiritual causes of illness from 600 BCE. This entailed taking greater interest in the body itself, identifying the links between cause and effect, how symptoms related to disease, and the success or failure of various therapies.[69]

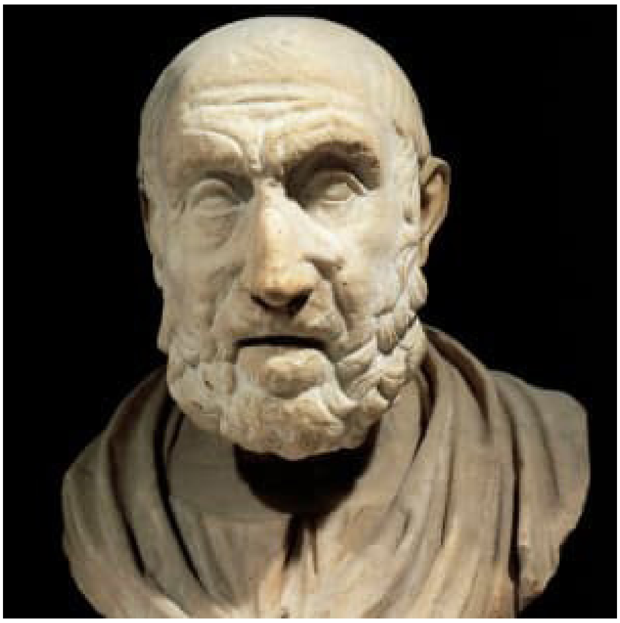
The most detailed Greek medical text is the Corpus Hippocraticum, which was compiled in Egypt between 323 and 31 BCE. While none are definitively ascribed to him alone, it consists of about 60 treatises attributed to Hippocrates (c460-c370 BCE). These address topics such as epidemics, joints, fractures, surgery, dreams, nutrition, dentistry, purgatives, and gynaecology. Some include case histories, while others discuss medical ethics and their relationship with non-medical subjects.[70.71]

The Corpus Hippocraticum indicated that patients could actually do things about their health, in particular regarding their diet and lifestyle. It also explained the importance of heat, cold and trauma in exacerbating or alleviating disease and disease symptoms, and recognised that a patient's constitution affected their susceptibility and severity of illness.

Yet, the Greeks' lack of distinction between philosophy and science led to the view that more could be discovered through reflection and argument than by practice and experiment. This led to a belief that disease could be caused by imbalances of the fluids or 'humours' – blood, yellow bile, black bile, and phlegm – within the body. As there were few clinical situations for which it could not provide a convincing (if factually wrong) explanation, the humoral theory of disease precluded any meaningful physiological research for over 2000 years.[72],[73],[74],[75] Furthermore, apart from some pioneer work by Herophilus of Chalcedon and Erasistratus of Ceos from c300 to 250 BCE, a prohibition on cadaver dissection curtailed human anatomical research until after 1300 CE.[76]

As previously indicated, the spiritual aspects of Greek health care were expressed via the demi-god Asclepius, son of the god Apollo and the mortal Koronis. After his mother died, Apollo gave Asclepius the gift of healing and the secrets of medicine using plants and herbs. He was also tutored by Cheiron, a wise centaur (half-man, half-horse) who also tutored other heroes such as Hercules, Achilles and Jason. In some traditions, Asclepius married the goddess of health Hygeia, and they had up to six children whose healing skills made them known as the Asclepiads. Asclepius was killed by Zeus because the gods became concerned that he could eventually raise the dead.[77],[78],[79]

The worship of Asclepius and his immediate descendants led to numerous temples ('asclepeion') throughout Greece and the Roman Empire, the first of which was established at Asclepius's birthplace at Epidaurus (40km south of Corinth) after c600 BCE. Their surroundings generally reflected the beauty of nature and wonder of the gods, while their amenities included water with special healing properties for drinking and bathing, gymnasia, an *abaton* (dream room), exhibitions of votives and testimonials of cure, and space for rituals and festivals.[80],[81]



*Bust of Hippocrates, marble copy of an original dated 400-300 BCE[82]*


*Replica Greek surgical instruments, c500-400 BCE[83] Note how they are made of bronze. The bullet-shaped item bottom centre was used for cupping.*

*Marble statue of Asclepius, the Greek demi-god of healing*[84] *Note the staff entwined by a single snake.*

*Terracotta votive offerings from the Asclepieion at Corinth, c500 BCE*[85],[86]

## Conclusion

The period from c10,000 to c300 BCE saw the first farms, hamlets and villages become towns and cities that either had to be defended, or could be used as bases for attack. Any fighting was probably conducted by informally organised groups, who were limited in the size and scope of their operations by the supplies and social structures to sustain them, as well as the lack of reasons to fight beyond the immediate needs of their communities. Such fighting is likely to have been largely ritualistic, with few combat casualties.

However, by c4000 BCE, urban centres had developed in modern Iraq to the point where they could sustain formed armies and – for better and for worse – provide them with the means and rationales to fight. These societal developments also made it possible to integrate disparate elements such as hoplites, peltasts, archers and chariots (later cavalry), into a single combat force. Notwithstanding the technological advances in weaponry and their employment since, the need for such integration remains extant, albeit not only between combat elements but also their logistic and other enabling support services, including health.

Meanwhile, the courage of the first Egyptian seafarers should not be underestimated, not only because their ships were essentially held together with string, but also because of their reliance on memory-based inshore coastal navigation. This would have posed a major limitation for their voyages to East Africa and India (particularly if the weather deteriorated off a lee shore), where unlike the Mediterranean, the waters and coastlines would have been largely unknown to them.

Naval warfare during this period entailed cramming hundreds of men aboard ships with very lightly built hulls and limited freeboard, most of whom were there to row rather than fight unless they were ashore. These men were susceptible to penetrating injuries from spears and arrows, while an apparently under-recognised risk in the literature pertains to blunt force trauma from the rower's own oars if they failed to unship them fast enough to prevent them being smashed. The use of ramming highlights a key concept of naval warfare throughout history: inflicting just enough damage for 'the cruel sea' to do the rest.

Despite such battles being fought close inshore, the more-or-less universal inability to swim meant that ending up in the water would have been fatal. Any surviving wounded were therefore limited to ships that were not sunk, or beached before sinking. The proximity to land and absence of on-board space would have led to their treatment ashore, on similar terms as if they had been fighting on land.

Although the Egyptians had developed effective surgical treatments for uncomplicated cuts, abrasions, and limb fractures by c2000 BCE, wound complications would still have had high morbidity and mortality, while head, spinal, chest and abdominal injuries remained almost universally fatal until modern times. Furthermore, their limited ability to diagnose medical conditions, and to match diagnosis to treatment, continued to limited the latter to non-technical emotional, social and (especially) spiritual support.

By 31 BCE, the Greeks had codified their medical knowledge into the Corpus Hippocraticum, which make Hippocrates the father of Western medicine, thereby dominating medical thought for the next 1800 years. While the Greeks' key contribution pertained to ascribing disease to material rather than supernatural causes, their lack of distinction between philosophy and science led to an aetiological theory of disease that barred meaningful physiological research, while a prohibition on cadaver dissection did likewise for anatomical studies.

The resulting stagnation in medical science had little effect on maritime operations until increasing overseas trade led to larger and more seaworthy ships, whose improved offensive and defensive capabilities in turn created further trading opportunities. Even now, this cycle remains pertinent to the economic wellbeing of many nations, including Australia.[87]

However, the worldwide expansion of this cycle from Europe from the end of the 15th century often led to the near or total annihilation of ship's crews from disease and non-battle injuries. It was not until the 18th century that the role of maritime medicine as an operational enabler was recognised, which not only facilitated the European settlement of Australia, but also British maritime dominance during and after the Napoleonic Wars.[88]

## Author

Dr Neil Westphalen graduated from Adelaide University in 1985 and joined the RAN in 1987. He is a RAN Staff Course graduate and a Fellow of the Royal Australian College of General Practitioners, the Australasian Faculty of Occupational and Environmental Medicine, and the Australasian College of Aerospace Medicine. He also holds a Diploma of Aviation Medicine and a Master of Public Health.

His seagoing service includes HMA Ships *Swan*, *Stalwart*, *Success*, *Sydney*, *Perth* and *Choules*. Deployments include DAMASK VII, RIMPAC 96, TANAGER, RELEX II, GEMSBOK, TALISMAN SABRE 07, RENDERSAFE 14, SEA RAIDER 15, KAKADU 16 and SEA HORIZON 17. His service ashore includes clinical roles at *Cerberus*, *Penguin*, *Kuttabul*, *Albatross* and *Stirling*, and staff positions as J07 (Director Health) at the then HQAST, Director Navy Occupational and Environmental Health, Director of Navy Health, Joint Health Command SO1 MEC Advisory and Review Services, and Fleet Medical Officer (2013-2016).

Commander Westphalen transferred to the Active Reserve in 2016.

## 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.

*Corresponding Author: Neil Westphalen, neil.westphalen@bigpond.com*
*Authors: N Westphalen [1,2]*
*Author Affiliations:*
*1 Royal Australian Navy Reserve*
*2 Navy Health Service, C/O Director Navy Health*

## References

1 Westphalen, N. 'Weapons, Ships and Medicine: Prehistoric Origins, Journal of Military and Veteran's Health, Vol 28 No 1 pp 16 available from www.jmvh.org.

2 Westphalen, N. 'Naval Medicine and the European Settlement of Australia', The Navy and the Nation: The Influence of the Navy on Modern Australia, Eds Stevens, D and Reeve, J, Allen and Unwin, Crow's Nest NSW, 2005, pp 69-83.

3 Weapons Universe, 'Bronze Age Weapons', available from http://www.weapons-universe.com/Swords/Bronze_Age_Weapons.shtml.

4 History World, 'History of Metallurgy', available from http://www.historyworld.net/wrldhis/PlainTextHistories.asp?historyid=ab16#1270.

5 [United States Air Force] Air University, 'A Short History of War: Chapter 1 – The Origins of War', available from http://www.au.af.mil/au/awc/awcgate/gabrmetz/gabr0002.htm.

6 Keegan, J, 1993. J. A History of Warfare, Hutchison: London, pp94-115.

7 Ancient History Encyclopedia, Mark, JJ, 'Ur', 2011, 28 Apr, available from https://www.ancient.eu/ur.

8 [United States Air Force] Air University, 'A Short History of War: Chapter 1 – The Origins of War', available from http://www.au.af.mil/au/awc/awcgate/gabrmetz/gabr0002.htm.

9 Ancient History Encyclopedia, Mark, JJ, 'Assyria', 2018, 10 Apr, available from https://www.ancient.eu/assyria.

10 Ancient Military.com, 'Egyptian weapons', available from http://www.ancientmilitary.com/egyptian-weapons.htm.

11 ABC Science, Hirshler, B, 'Horses first ridden 5500 years ago', 2009, 06 Mar, available from http://www.abc.net.au/science/articles/2009/03/06/2509129.htm

12 Ancient History Encyclopedia, Plubins, RQ, 'Chariot', 2013, 06 Mar, available from https://www.ancient.eu/chariot.

13 Ancient History Encyclopedia, Σταύρος, 'Egyptian Soldiers: Illustration', 2016, 03 Oct, available from https://www.ancient.eu/image/5827.

14 Weapons and Warfare: History and Hardware of Warfare, 'Egyptian Chariot Warfare', 2018, 2 Nov, available from https://weaponsandwarfare.com/2015/11/02/egyptian-chariot-warfare.

15 Ancient History Encyclopedia, 'Egyptian Bronze Sword', 2016, 03 Oct, available from https://www.ancient.eu/image/5826.

16 Ancient History Encyclopedia, Cartwright, M, 'Ancient Greek Warfare, 2018, 27 Mar, available from https://www.ancient.eu/Greek_Warfare; also

17 Ancient History Encyclopedia, Mark, JJ, 'The Greek Phalanx', 2012, 18 Jan, available from https://www.ancient.eu/article/110/the-greek-phalanx.

18 For a modern example of a crowd control failure, see The Telegraph, Sawer, P, 'What happened at Hillsborough in 1989?', 2017, 28 Jun, available from https://www.telegraph.co.uk/news/0/happened-hillsborough-1989.

19 Battles of the Ancients, Hughes, T, 'The Wars of the Diadochi: Eumenes and Craterus', 2018, 11 Apr, available from http://turningpointsoftheancientworld.com/index.php/tag/ancient-greece.

20 DigitalCommons@University of Nebraska – Lincoln, Winter TN, 'The Place of Archery in Greek Warfare', pp 3-4, 1990, 01 Jan at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1008&context=classicsfacpub.

21 The Battle of Thermopylae was popularised in the highly fictionalised 2007 movie 300: see History vs Hollywood, '300 (2007)', available from http://www.historyvshollywood.com/reelfaces/300spartans.php. For a rather more factual description, see Ancient History Encyclopedia, Cartwright, M, 'Thermopylae', 2013, 16 Apr, available from https://www.ancient.eu/thermopylae.

22 Realm of History: the future lies in the past, '10 things you may not have known about the Greek Hoplites', available from https://www.realmofhistory.com/2016/01/19/10-things-you-may-not-have-known-about-the-greek-hoplites.

23 Ancient History Encyclopedia, Manske, M, 'Peltast: Illustration', 2013 12 Feb, available from https://www.ancient.eu/image/1060.

24 Battles of the Ancients, Hughes, T, 'From secretary to strategist: why Eumenes was so remarkables', 2018, 11 Apr, available from http://turningpointsoftheancientworld.com/index.php/tag/ancient-greece.

25 Wachsmann, S, 'Paddled and Oared Ships before the Iron Age', Conway's History of the ship, Volume 2: The Age of the Galley, 1995, Gardner R ed, London: Conway Maritime Press, p 10.

26 Wachsmann, S, 'Paddled and Oared Ships before the Iron Age', Conway's History of the ship, Volume 2: The Age of the Galley, 1995, Gardner R ed, London: Conway Maritime Press, p 10-11.

27 Facts and Details, 'Ships and boats and river and sea travel in ancient Egypt: ancient Egyptian ships', available from http://factsanddetails.com/world/cat56/sub404/entry-6147.html#chapter-1.

28 Egypt origins, 'The Khufu boat', available from http://www.egyptorigins.org/boats.htm.

29 Ancient History Encyclopedia, Mark, JJ, 'Ancient Egyptian warfare', 2016, 03 Oct, available from https://www.ancient.eu/Egyptian_Warfare.

30 Ancient History Encyclopedia, Bhandarkar V, 'Khufu's Ship,' 2017,11 May, available from https://www.ancient.eu/uploads/images/6614.jpg?v=1494489977.

31 Jenkins, N, Ross, J. The boat beneath the pyramid: King Cheop's royal boat,1980, New York,: Holt, Rhinehart and Winston, available http://www.gizapyramids.org/static/pdf%20library/jenkins_boat.pdf.

32 Jenkins, N, Ross, J. The boat beneath the pyramid: King Cheop's royal boat,1980, New York,: Holt, Rhinehart and Winston, available http://www.gizapyramids.org/static/pdf%20library/jenkins_boat.pdf.

33 The British Museum, Ward, C, 'The British Museum: Building Pharaoh's Ships: Cedar, Incense and Sailing the Great Green', 2012, available from http://www.britishmuseum.org/PDF/Ward.pdf.

34 The British Museum, Ward, C, 'The British Museum: Building Pharaoh's Ships: Cedar, Incense and Sailing the Great Green', 2012, available from http://www.britishmuseum.org/PDF/Ward.pdf.

35 Ancient History Encyclopedia, Deror avi, 'Egyptian Warship Model: Illustration', 2016, 03 Oct, available from https://www.ancient.eu/image/5825.

36 militaryfactory.com, Potts, JR, 'Pentacontor oared and sail-powered ram galley', 2013, 08 Apr, available from https://www.militaryfactory.com/ancient-warfare/detail.asp?ancient_id=penteconter.

37 WikiVisually, 'Treenail', available from https://wikivisually.com/wiki/Treenail.

38 Ancient History Encyclopedia, Cartwright, M, 'Trireme', 2012, 31 May, available from https://www.ancient.eu/trireme.militaryfactory.com, Potts, JR, 'Pentacontor oared and sail-powered ram galley', 2013, 08 Apr, available from https://www.militaryfactory.com/ancient-warfare/detail.asp?ancient_id=penteconter.

39 Experience in both World Wars (in particular actions between Atlantic convoy escorts and submarines) confirmed that deliberately ramming highly manoeuvrable opponents is very difficult unless they had been disabled first. It seems likely the same situation applied 2500 years ago.

40 PBS, The Greeks: Crucible of Civilization, 'The trireme', available from http://www.pbs.org/empires/thegreeks/htmlver.

41 Ancient History Encyclopedia, Cartwright, M, 'Salamis', 2013, 05 May, available from https://www.ancient.eu/salamis.

42 Ancient History Encyclopedia, Cartwright, M, 'Salamis', 2013, 05 May, available from https://www.ancient.eu/salamis.

43 TrekEarth, 'Regatta 2010 Argo ', available from https://www.trekearth.com/gallery/Europe/Greece/Thessaly/Magnisia/Volos/photo1216070.htm.

44 The National Herald, 'The Trireme Olympias to Sail Again in July & September, Hellenic Navy Announces', 2018, 18 Aug, available from https://www.thenationalherald.com/167423/trireme-olympias-sail-july-september-hellenic-navy-announces.

45 Wikipedia, 'Depiction of the position of the rowers in three different levels (from top: thranitai, zygitai and thalamitai) in a Greek trireme', available from https://en.wikipedia.org/wiki/Hellenistic-era_warships#/media/File:Trireme_cut-fr.svg.

46 Articles of Interest, 'The Bay of Salamis: the naval battle in 480 BCE which saved the West and by extension western civilization', 2016, 16 Sep, available from https://michaeldevillier.blogspot.com/2016/09/the-bay-of-salamis-naval-battle-in-480.html.

47 For example, see Posadzski, P, Watson, L.K, Ernst, E, Clinical Medicine (London), 'Adverse effects of herbal medicines: an overview of systematic reviews', Vol 13 No 1 pp. 7–12, Feb 2013. Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5873713.

48 Ancient History Encyclopedia, Mark, JJ, 'Egyptian Medicine', 2017, 17 Feb, available from https://www.ancient.eu/Egyptian_Medicine.

49 Egyptian Gods and Goddesses, 'Egyptian Gods: Heka', available from http://egyptian-gods.org/egyptian-gods-heka.

50 It should be noted however, that a winged staff entwined by two serpents has actually been used for millennia to represent trade, eloquence, negotiation, alchemy and wisdom, rather than medicine. The caduceus was first misapplied by the US Army's Medical Corps for its badge in 1902, and has been misused throughout much of America since.

The correct medical symbol is actually the Rod of Asclepius, which consists of a single serpent entwined around a staff without wings. See Blayney, K, 'The Caduceus vs the Staff of Asclepius' (Asklepian), October 2005, available from http://drblayney.com/Asclepius.html

51 Ancient Egypt online, 'Sekhmet', available from https://www.ancientegyptonline.co.uk/sekhmet.html

52 Ancient Egypt online, 'Serket', available from https://www.ancientegyptonline.co.uk/serqet.html.

53 Ancient Egypt online, 'Sobek', available from https://www.ancientegyptonline.co.uk/sobek.html.

54 Ancient Egypt online 'Nefertum', available from https://www.ancientegyptonline.co.uk/nefertum.html.

55 H Grevel and Co: London, Griffith, FL, Thompson H, eds, The Demotic Magical Papyrus of London and Leiden, 1904, available from http://www.etana.org/sites/default/files/coretexts/15139.pdf.

56 Journal of Family Planning and Reproductive Health Care, Smith, L, The Kahun Gynaecological Papyrus: ancient Egyptian medicine', available from https://srh.bmj.com/content/familyplanning/37/1/54.full.pdf, 2011;Vol 37, pp 54–55.

57 New World Encyclopedia, 'Edwin Smith Papyrus', available from http://www.newworldencyclopedia.org/entry/Edwin_Smith_Papyrus.

58 'The Hearst medical papyrus: hieratic text in 17 facsimile plates in collotype', available from https://wellcomelibrary.org/item/b28038125#?c=0&m=0&s=0&cv=8&z=-0.9625%2C-0.0573%2C2.925%2C1.4899.

59 New World Encyclopedia, 'Ebers Papyrus', available from http://www.newworldencyclopedia.org/entry/Ebers_Papyrus.

60 The British Museum Quarterly, Hall, HR, 'The Chester-Beatty Egyptian Papyri', 1930, Sep, Vol. 5, No. 2. pp. 46-47, available from https://www.jstor.org/stable/4421178?read-now=1&loggedin=true&seq=1#page_scan_tab_contents,

61 Ancient History Encyclopedia, Mark, JJ, 'Egyptian Medicine', 2017, 17 Feb, available from https://www.ancient.eu/Egyptian_Medicine.

62 Ancient History Encyclopedia, Mark, JJ, 'Egyptian Medicine', 2017, 17 Feb, available from https://www.ancient.eu/Egyptian_Medicine.

63 Ebers Papyrus', New World Encyclopedia, available from http://www.newworldencyclopedia.org/entry/Ebers_Papyrus.

64 Dahl, J, 'Egyptian Medical Instruments Ancient History Encyclopedia, 16 February 2017, available from https://www.ancient.eu/image/6364.

65 'Ancient Egyptian Medicine', available from http://www.crystalinks.com/egyptmedicine.html.

66 Mythology Wiki, 'Heka', available from http://mythology.wikia.com/wiki/Heka?file=Heka.jpg.

67 Ancient History Encyclopedia, Amin, OSM, 'Prosthetic Toe of Painted Cartonnage',2016, 17 Jun, available from https://www.ancient.eu/image/5226.

68 Holloway, A, 'From jewel-capped teeth to golden bridges – 9,000 years of dentistry', 08 March 2014, available from https://www.ancient-origins.net/human-origins-science/jewel-capped-teeth-golden-bridges-9000-years-dentistry-001427.

69 Ancient History Encyclopedia, Cartwright M, 'Ancient Greek Medicine', 2018, 11 Apr, available from https://www.ancient.eu/Greek_Medicine.

70 Ancient History Encyclopedia, Cartwright M, 'Ancient Greek Medicine', 2018, 11 Apr, available from https://www.ancient.eu/Greek_Medicine. See also

71 Ancient History Encyclopedia, Cartwright, M, 'Hippocrates', 2016, 20 Apr, available from https://www.ancient.eu/Hippocrates.

72 Ancient History Encyclopedia, Cartwright M, 'Ancient Greek Medicine', 2018, 11 Apr, available from https://www.ancient.eu/Greek_Medicine.

73 Antiqua Medicina: from Homer to Versalius, 'Homer to Hippocrates: Early Greek Medicine', available from http://exhibits.hsl.virginia.edu/antiqua/homer.

74 Antiqua Medicina: from Homer to Versalius, 'The Hippocratic Corpus', available from http://exhibits.hsl.virginia.edu/antiqua/humoral.

75 For a history describing how medicine has arguably done more harm than good until comparatively recent times (and possibly continues to do so), see Wootton, D, 2006, Bad Medicine: Doctors Doing Harm Since Hippocrates, Oxford University Press: London, 2006; also 'Bad Medicine: Doctors Doing Harm Since Hippocrates', available from http://www.badmedicine.co.uk.

76 Anatomy and Cell Biology, Ghosh, SK, Human cadaveric dissection: a historical account from ancient Greece to the modern era', 2015, 22 Sep, Volume 48 Number 3 pp. 153–169, available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4582158;.

77 Cartwright, M, 'Asclepius', Ancient History Encyclopedia, 20 June 2013, available from https://www.ancient.eu/Asclepius.

78 Hart GD, Asclepius: The God of Medicine, 2000, London: Royal Society of Medicine Press.

79 Cartwright, M, Ancient History Encyclopedia, 'Centaur', 2012, 05 Oct, available from https://www.ancient.eu/centaur.

80 Hart GD, Asclepius: The God of Medicine, 2000, London: Royal Society of Medicine Press.

81 The Votives Project, Graham E-J, 'Anatomical votive reliefs as proof for specialisation at ancient Greek healing sanctuaries?', 2017, 04 May, available from https://thevotivesproject.org/2017/05/04/anatomical-votive-specialisation.

82 Biography, 'Hippocrates Biography: Doctor (460 BCE–370 BCE)', available from https://www.biography.com/people/hippocrates-082216.

83 The History of Ancient Greece Podcast, '078 Healing and Medicine', available from http://www.thehistoryofancientgreece.com/2018.

84 Ancient History Encyclopedia, Cartwright, M, 'Asclepius', 2013, 20 Jun, available from https://www.ancient.eu/Asclepius.

85 The Votives Project, Graham, E-J, 'Votives on display (part 1)', 2015, 19 Apr, available from https://thevotivesproject.org/2015/04/19/votives-on-display-part-1.

86 Archaeological museum of ancient Corinth, 'Sanctuary of Asklepieion', available from https://www.corinth-museum.gr/en/archaeological-site/sanctuary-of-asklepieion.

87 See Sea Power Centre – Australia. 'Australian Maritime Doctrine : RAN Doctrine 1', 2$^{nd}$ edition, 2010, available from http://www.navy.gov.au/sites/default/files/documents/Amd2010.pdf

88 Lloyd, C, Coulter, JLS. Medicine and the Navy 1200-1900. Volumes 3 (1714-1815) and 4 (1815-1900), London: E&S Livingstone,1961, 1963

# The Effects of Depression on Success in Male Soldiers Sexually Transmitted Disease and Reproductive Health Education

*M Özdemir, H Yalçınöz Baysal, R Özkan, A Baysal*


## Abstract

**Aims:** In this study, we aimed to investigate the effect of depression on education regarding sexually transmitted diseases and reproductive and sexual health.

**Methods:** The study was conducted in 98 healthy private soldiers. Sociodemographic characteristics were recorded. The participants filled out the 'reproductive health knowledge evaluation form' (RHKEF) and Beck Depression Inventory (BDI) before the two-hour reproductive and sexual health education intervention. The RHKEF was repeated four weeks after the intervention. Higher than the median increase in the RHKEF score was accepted as a meaningful improvement. The effects of study variables and depression status on the RHKEF score change after the intervention was evaluated by using univariate and multivariate analyses.

**Results:** Among the study population, 35 soldiers (35.7%) were at risk of depression. The rate of depression was higher in soldiers who were living in urban areas compared with those living in rural areas. The mean RHKEF score increased from 16.9±3 at the baseline visit to 18.7±2.2 after the education. There was no association between the change in RHKEF score and depression or sociodemographic characteristics. There was a negative correlation between the age and change in the RHKEF score (r=-0.208, p=0.04) in univariate analysis. In the multivariate analysis, only the absence of depression had a positive effect on RHKEF score improvement. The OR was 2.08 (95% CI: 1.78-3.5, p=0.042).

**Conclusions:** The rate of depression risk is relatively high in healthy private soldiers. An education intervention for reproductive and sexual health seems to be beneficial in this population. Depression seems to influence the effects of education on reproductive and sexual health adversely.


**Keywords:** depression, education, military, sexually transmitted disease.

## Introduction

Sexually transmitted diseases (STDs), generally acquired by sexual contact, have preventable causes and severe complications. *Chlamydia trachomatis* and *Neisseria gonorrhoeae* are the most common bacterial STDs in Turkey and worldwide.[1, 2] Young adults are at higher risk of STDs.[3] The risk is even higher in the presence of certain factors such as unprotected sexual contact, multiple sexual partners, illicit drug use, being uncircumcised and overseas travel. Abstinence from unsafe sexual contact, encouragement of condom use, delaying the age of the first sexual contact, facilitation of treatment, education of people at risk, treatment of partners along with patients when needed and implementation of routine check-ups are essential in the prevention and reduction of STDs.[4]

Among young adults, military recruits are in an age group with high levels of sexual activity. The peak age of STD transmission is between 20 and 24 years. In Turkey, military service is mandatory for every 20-year-old male Turkish citizen, and the duration may be one, six or 12 months according to education and health status.[5,6] Besides being away from their family, social and workplace environments, the soldiers need to get used to a new place and being on duty both physically and psychologically. Furthermore, they face many challenges, such as a restricted personal life, lack of sexual relationships, living in a crowded environment, poor hygiene and harsh weather conditions.[7] Such conditions may lead to psychological problems in soldiers with several studies indicating that psychological problems are associated with military attrition among soldiers.[8,9]

Depression may influence information processing, reduce the motivation for behaviour change and undermine sustained change.[10,11] Depressive symptoms commonly develop along with the onset of STDs. Depression is also associated with low condom use rates, casual relationships, multiple sexual partners, sexual intercourse with sex workers and sexual intercourse while under the influence of illicit drugs.[12-14] Several studies suggest that depression may diminish the benefits and efficacy of treatment of STDs.[15-17] Untreated depression may also hinder interventions that aim to reduce high-risk sexual activity.

Because soldiers may encounter conditions that have a high risk for STDs, raising awareness of this issue is essential. Condom use is a cheap and effective measure to prevent STDs. As well as the social benefits, lecturing on this subject to military populations would be beneficial not only for the military service period but also for the rest of their lives.[18] The beneficial effects of reproductive and sexual health education on the knowledge level of soldiers was shown previously.[19]

In the present study, we aimed to investigate the effect of depression scores on the success of education about reproductive and sexual health, and STDs in soldiers.

## Methods

The present semi-experimental study was carried out in a military troop between October 2018 and November 2018, after obtaining the required permission from Erzurum Garrison Command. The study population consisted of 98 healthy private Turkish soldiers between the ages of 21 and 26. Military officers (12 soldiers) and those who did not want to participate (14 soldiers) were excluded from the study. The participants had to attend all education sessions to be included in the study. All soldiers who consented to participate in the study filled out the 'reproductive health knowledge evaluation form (RHKEF)' and 'Beck Depression Inventory (BDI)' before the education intervention. Subsequently, the reproductive and sexual health education, which lasted around two hours, was provided by two physicians (one of whom is a public health specialist) and a nurse (doctorate in public health). The RHKEF was repeated four weeks after the education.

The questionnaires in the present study were as follows; six-item 'participant demographic information form', a 25 item RHKEF and a 21 item BDI.

***Reproductive health knowledge evaluation form:*** The authors prepared a 25 item 'true or false' questionnaire according to the literature in order to assess the knowledge level of the participants regarding reproductive and sexual health.

***Beck Depression Inventory:*** The self-administered questionnaire and the Turkish validity and reliability study of the test was performed by Hisli et al.[20] Each response to the 21 questions is scored between 0–3 points to determine the level of depression. A total score of 1–10, 11–16, 17–20, 21–30, 31–40 and 41–63 indicate regular ups and downs, mild mood disturbance, borderline clinical depression, moderate depression, severe depression and extreme depression, respectively.

***Ethical aspects*****:** The required ethical committee approval (date: 21 May 2018; approval number: 37732058-514.10) and permission from the relevant institutions were obtained.

***Statistical analysis*****:** Analysis of the data was performed using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). Histogram graphics and Shapiro Wilk test evaluated the normal distribution of the data. Categorical variables were compared by using Pearson chi-square and Fisher's exact tests. Mann-Whitney U and Kruskal Wallis tests compared the nonparametric data. The correlation between continuous variables was assessed using Spearman correlation tests. The median split method was used to determine the median change in the RHKEF score after the education. A meaningful change was defined as a higher increase than the median value in the RHKEF score. Multivariate binary logistic regression analysis was used to determine the factors that are independently associated with an increase in the RHKEF score. A two-sided p-value of <0.05 was used to define statistical significance.

## Results

The study population consisted of 98 healthy private soldiers between the ages of 21 and 26. Among the participants, 72.4% lived in urban areas, 92.9% were single, 55.1% were high school graduates, 83.7% had a private room before the military service and 74.5% had a history of sexual activity. According to the BDI, 35 soldiers were at risk of depression. The rate of depression was significantly higher in soldiers living in urban areas compared with those living in rural areas (42.3% vs 18.5%, respectively; see Table 1).

**Table1. The comparison of subjects with and without depression**

| | | Depression | | | | p |
|---|---|---|---|---|---|---|
| | | Absent | | Present | | |
| | | n | (%) | n | (%) | |
| Age(median-IQR) | | 22 | (21-26) | 22 | (21-24) | 0.671a |
| Living area | Urban | 41 | (57.7) | 30 | (42.3) | **0.028** b |
| | Rural | 22 | (81.5) | 5 | (18.5) | |
| Marital status | Single | 59 | (64.8) | 32 | (35.2) | 0.698 c |
| | Married | 4 | (57.1) | 3 | (42.9) | |
| Education status | Left primary school | 1 | (50) | 1 | (50) | 0.545 c |
| | Primary school graduate | 15 | (68.2) | 7 | (31.8) | |
| | High school graduate | 32 | (59.3) | 22 | (40.7) | |
| | College/university graduate | 15 | (75) | 5 | (25) | |
| Private room | Present | 55 | (67.1) | 27 | (32.9) | 0.192 b |
| | Absent | 8 | (50) | 8 | (50) | |
| History of sexual activity | Present | 48 | (65.8) | 25 | (34.2) | 0.604 b |
| | Absent | 15 | (60) | 10 | (40) | |

*[a] Mann Whitney U test, [b] Chi-square test, [c] Fisher's exact test. Significant p values are presented with bold text*

**Table2. The univariate analyses for the association between the change in the RHKEF score and the socio-demographic characteristics**

| | | The change in RHKEF score | | p |
|---|---|---|---|---|
| | | Median | IQR | |
| Living area | Urban | 1 | 0-3 | 0.171a |
| | Rural | 2 | 1-4 | |
| Marital status | Single | 1 | 1-4 | 0.077 a |
| | Married | 0 | (-1)-2 | |
| Education status | Left primary school | 0.5 | (-1)-2 | 0.150 b |
| | Primary school graduate | 2.5 | 1-4 | |
| | High school graduate | 1 | 0-4 | |
| | College/university graduate | 1 | 0-2.5 | |
| Private room | Present | 1 | 1-3 | 0.409 a |
| | Absent | 15 | (-1)-3 | |
| History of sexual activity | Present | 1 | 0-3 | 0.360 a |
| | Absent | 2 | 1-4 | |
| Presence of depression | No | 2 | 1-4 | 0.146a |
| | Yes | 1 | (-1)-3 | |
| Severity of depression | Moderate depression | 1.5 | (-0.5)-3 | 0.937 a |
| | Severe depression | 1 | (-1)-2.5 | |

*RHKEF: reproductive health knowledge evaluation form [a] Mann Whitney U test, [b] Kruskal Wallistest. Significant p values are presented with bold text*

Among the 35 soldiers who were at risk of depression, 16 had severe risk. There was no significant association between the severity of depression and the sociodemographic characteristics.

While the mean RHKEF score was 16.9±3 (median 17) at the baseline visit, it increased to 18.7±2.2 (median 19) after the education intervention. There was no association between the change in the RHKEF score and the presence of depression or sociodemographic characteristics. (see Table 2 and Figure 1).

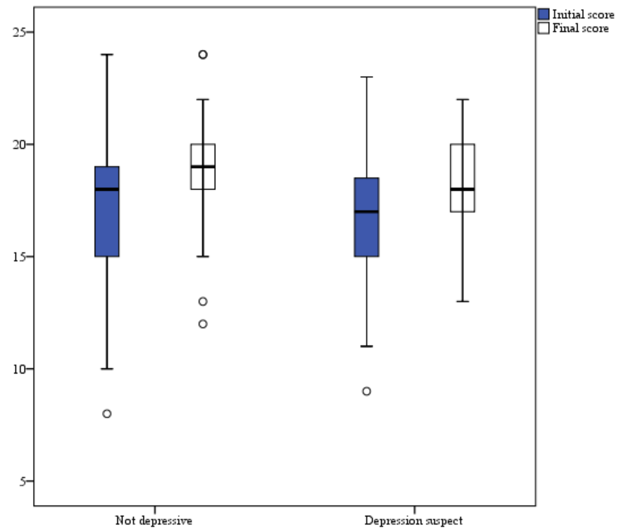



*Figure 1. The change in RHKEF score according to depression status*

The age of the soldiers had a moderate and positive correlation with the initial RHKEF score (r=0.345, p=0.001), a weak and positive correlation with the final RHKEF score (r=0.254, p=0.012), and a weak and negative correlation with the change in RHKEF score (r=-0.208, p=0.04; Figure 2).

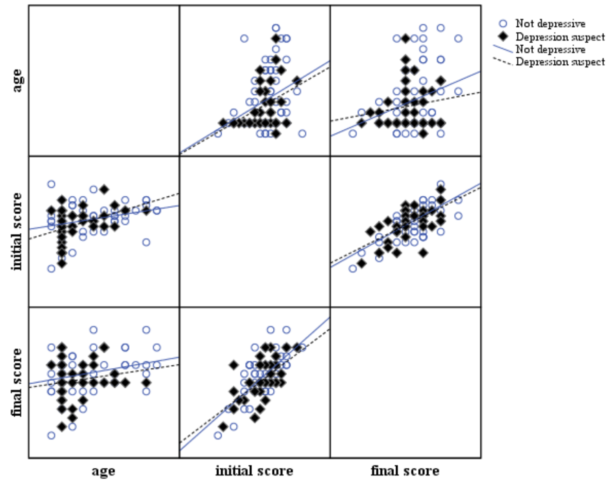



*Figure 2. The correlation between the soldiers' ages and their initial and final RHKEF scores*

The median change in the RHKEF score was 1 point. Among the study variables, only depression was independently associated with a meaningful change in the RHKEF score. According to the multivariate logistic regression analysis, the absence of depression increased the likelihood of an increase in the RHKEF score greater than 1 point by a factor of 2.08 (95% CI: 1.78–3.5, p=0.042; Table 3).

**Table3. The multivariate analysis for the association of a meaningful change in the RHKEF score and the study variables**

| | p | OR | 95% CI | |
|---|---|---|---|---|
| | | | Lower | Upper |
| Age | 0.299 | 0.976 | 0.932 | 1.022 |
| Not depressive | **0.042** | 2.084 | 1.789 | 3.500 |
| Living in rural areas | 0.437 | 1.584 | 0.497 | 5.056 |
| Single | 0.16 | 3.116 | 0.431 | 22.548 |
| Does not have a private room | 0.539 | 1.464 | 0.434 | 4.936 |
| No history of sexual activity | 0.368 | 1.597 | 0.577 | 4.424 |

*RHKEF: reproductive health knowledge evaluation form*

*Significant p values are presented with bold text.*

## Discussion

Nearly 40% of people seeking care at STD clinics experienced psychological problems immediately before or at the time of their visit.[21,22] One of these studies reported that 14% of women and 23% of men experienced a major depressive disorder,[22] which is a substantially higher rate than general practice patients and the US population.[23,24] Several studies indicated that depression is an important risk factor for various diseases, including STDs.[25–28] Depression may also adversely influence essential life functions, such as eating, drinking and learning.[29, 30]

Factors such as staying away from family, change of habits or change in the environment may accelerate depression. In the present study, among the variables, only the population density significantly affected depression. The rate of depression was higher in soldiers living in urban areas than those living in rural areas (42.3% vs 18.5%, respectively). This finding is consistent with previous studies. Urbanisation is not only a risk factor for cardiovascular disease and metabolic disorders such as diabetes mellitus but also mental diseases such as depression.[31–33] In Turkey, a migration wave from rural to urban areas began in the second half of the 20th century.[34] However, in our country, urban areas have become a risk factor in various aspects because of rapid urbanisation, inadequate infrastructure and adaptation problems.[35] In the present study, we evaluated the association of depression with relevant factors (age, marital status, education status, etc.) reported in the literature, but there was no significant relationship found.

In contrast to previous studies,[36,37] married soldiers had a higher risk of depression compared to single ones. However, previous studies focused mostly on the association between depression and marital status in women.[38,39] Concerning age, Kessler et al.[40] reported that while depression affected all age groups, the middle-aged individuals were at the highest risk level. The present study consisted of middle-aged individuals, but it did not include other age groups so we could not adequately assess the relationship between age and depression.

Although the increase in the RHKEF score was higher in the soldiers without depression than those with depression, the difference was not statistically significant (median value was 2 vs 1, respectively). In the multivariate regression analysis, depression was independently associated with the increase in the RHKEF score, and soldiers without depression were 2.08 times (95% CI: 1.78–3.5, p=0.042) more likely to benefit from reproductive and sexual health education. As mentioned in previous studies, depression may reduce the motivation to change behaviour, interfere with information processing or undermine sustained change.[10,11] Furthermore, several studies suggest that depression may negate the benefits of intervention and inhibits efficacy.[16,41] Holden et al.[17] investigated the influence of depression on sexual risk reduction and STD infection with a cognitive/behavioural intervention (SAFE trial). Although the depressed women had a higher behavioural risk at baseline, the intervention was similarly successful in reducing reinfection and high-risk behaviour among depressed and non-depressed subjects.

A few limitations of the present study must be noted. First, the study utilised only subjective measures of depression at the individual level. In this context, further clinical evaluation is needed for an accurate diagnosis of depression. Another limitation is that such education interventions may not be sufficient enough when they are provided for subjects in a compulsory environment, as in the present study. Therefore, this may be reflected in the quiet small change in median RHKEF scores pre and post-intervention.

## Conclusions

The lack of determination of the correct target group for reproductive and sexual health education may fail to obtain expected results from such interventions. The difficulty of succeeding in reproductive and sexual health education programs has been reported, but the studies were conducted on female populations alone.[42–44] In this context, basic military training is a unique opportunity to perform such programs. However, depression may reduce the efficacy of this educational intervention.

Providing coordinated care can reduce the prevalence of STDs among soldiers with depression and be a crucial step in reducing the morbidity associated with poor mental health. The present study indicates an independent and adverse effect of depression on reproductive and sexual health education programs. Therefore, enhanced and coordinated health care for better mental health in primary care is vital for family planning and to prevent STDs.

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Literature Search: M.Ö., R.Ö.İ H.Y.B., A.B. Writing: M.Ö., H.Y.B., A.B.; Critical review: H.Y.B.

## Conflict of Interest

The authors declared they do not have anything to disclose regarding conflict of interest concerning this manuscript.

*Corresponding Author: Özdemir Mikail, mika367@gmail.com*
*Authors: Özdemir Mikail1,2, YALÇINÖZ BAYSA Hasret[3,4,] Özkan Recep[1,5] Baysal Abdullah[1,5]*
*Author Affiliations:*
*1 Ministry of Health of Turkey,*
*2 Osmaniye Tuberculosis Dispensary*
*3 Erzurum Ataturk University*
*4 Department of Public Health Nursing*
*5 Palandoken District Health Directorate*

## References

1. Centers for Disease Control and Prevention. Sexually Transmitted Disease Surveillance 2017. Atlanta: U.S. Department of Health and Human Services; 2018.
2. Akgul A, Kadioglu A, Koksal MO, Ozmez A, Agacfidan A. Sexually transmitted agents and their association with leucocytospermia in infertility clinic patients. Andrologia. 2018;50(10):e13127.
3. Türkiye Sağlık Bakanlığı. Ana Çocuk Sağlığı ve Aile Planlaması Genel Müdürlüğü. Ana ve Çocuk Ölümlerini Önleme Projesi Web sayfası: http://www.saglik.gov.tr. 2005.
4. Lucas D, Buntin D. Approach to the patient with sexually transmitted disease. Freedberg IM, Eisen AZ, Wolff K, Austen KF, Goldsmith LA, Katz SI, Fitzpatrick TB, editors, Dermatology in general medicine New York: McGraw-Hill. 1999:2547–51.
5. Malone JD, Hyams KC, Hawkins RE, Sharp TW, Daniell FD. Risk factors for sexually-transmitted diseases among deployed U.S. military personnel. Sex Transm Dis. 1993;20(5):294–8.
6. Şaşmaz S, Çalka Ö, Altınyazar C. Kuzey Kıbrıs Türk Cumhuriyeti'nde görev yapan askerlerde cinsel yolla bulaşabilen hastalıkların sıklığı. Çukurova Üniversitesi Tıp Fak Derg. 2003;28(3):88–93.
7. Adler AB, Cawkill P, Van den Berg C, Arvers P, Puente J, Cuvelier Y. International military leaders' survey on operational stress. Military Medicine. 2008;173(1):10–6.
8. Booth-Kewley S, Larson GE, Ryan MA. Predictors of Navy attrition. I. Analysis of 1-year attrition. Military medicine. 2002;167(9):760–9.
9. Hoge CW, Lesikar SE, Guevara R, Lange J, Brundage JF, Engel Jr CC, et al. Mental disorders among US military personnel in the 1990s: association with high levels of health care utilization and early military attrition. American Journal of Psychiatry. 2002;159(9):1576–83.
10. Olvera RL, Semrud-Clikeman M, Pliszka SR, O'donnell L. Neuropsychological deficits in adolescents with conduct disorder and comorbid bipolar disorder: a pilot study. Bipolar Disorders. 2005;7(1):57–67.
11. Harmer CJ, Shelley NC, Cowen PJ, Goodwin GM. Increased positive versus negative affective perception and memory in healthy volunteers following selective serotonin and norepinephrine reuptake inhibition. American Journal of Psychiatry. 2004;161(7):1256-63.
12. Ramrakha S, Caspi A, Dickson N, Moffitt TE, Paul C. Psychiatric disorders and risky sexual behaviour in young adulthood: cross sectional study in birth cohort. Bmj. 2000;321(7256):263–6.
13. Williams CT, Latkin CA. The role of depressive symptoms in predicting sex with multiple and high-risk partners. JAIDS Journal of Acquired Immune Deficiency Syndromes. 2005;38(1):69–73.
14. Shrier LA, Harris SK, Sternberg M, Beardslee WR. Associations of depression, self-esteem, and substance use with sexual risk among adolescents. Preventive medicine. 2001;33(3):179–89.
15. Murphy DA, Durako SJ, Moscicki A-B, Vermund SH, Ma Y, Schwarz DF, et al. No change in health risk behaviors over time among HIV infected adolescents in care: role of psychological distress. Journal of adolescent Health. 2001;29(3):57–63.
16. Baydar N, Reid MJ, Webster-Stratton C. The role of mental health factors and program engagement in the effectiveness of a preventive parenting program for Head Start mothers. Child development. 2003;74(5):1433–53.

17. Holden AE, Shain RN, Miller WB, Piper JM, Perdue ST, Thurman AR, et al. The influence of depression on sexual risk reduction and STD infection in a controlled, randomized intervention trial. Sexually transmitted diseases. 2008;35(10):898.
18. Coşkun Ö, Karakaş A. Askerlerde Cinsel Yolla Bulaşan Enfeksiyonlar ve Korunma. TAF Preventive Medicine Bulletin. 2012;11(3).
19. Kokcu AT, Sayligil O. An intervention study to assess knowledge and attitude about reproductive health among Turkish Armed Forces. JPMA The Journal of the Pakistan Medical Association. 2016;66(12):1571–6.
20. Hisli N. Beck depresyon envanterinin universite ogrencileri icin gecerliligi, guvenilirligi.(A reliability and validity study of Beck Depression Inventory in a university student sample). J Psychol. 1989;7:3–13.
21. Erbelding EJ, Hummel B, Hogan T, Zenilman J. High rates of depressive symptoms in STD clinic patients. Sexually transmitted diseases. 2001;28(5):281–4.
22. Hutton HE, Lyketsos CG, Zenilman JM, Thompson RE, Erbelding EJ. Depression and HIV risk behaviors among patients in a sexually transmitted disease clinic. American Journal of Psychiatry. 2004;161(5):912–4.
23. Zich JM, Attkisson CC, Greenfield TK. Screening for depression in primary care clinics: the CES-D and the BDI. The International Journal of Psychiatry in Medicine. 1990;20(3):259–77.
24. Regier DA, Farmer M, Rae D, Myers J, Kramer M, Robins L, et al. One-month prevalence of mental disorders in the United States and sociodemographic characteristics: the Epidemiologic Catchment Area study. Acta Psychiatrica Scandinavica. 1993;88(1):35–47.
25. Taşar MA, Tapçı AE, Baydar A, Dallar YB, Çakır İ. Is postnatal depression and anxiety of mothers effective on weight gain of the infants. Gulhane Medical Journal. 2016;58(3):233–7.
26. Çivi S, Kutlu R, Çelik HH. Depression status and the factors affecting the quality of life in the relatives of the patients with cancer. Gulhane Medical Journal. 2011;53(4):248–53.
27. Yu M, Zhang X, Lu F, Fang L. Depression and Risk for Diabetes: A Meta-Analysis. Canadian journal of diabetes. 2015;39(4):266–72.
28. Jenkins WD, Botchway A. Young adults with depression are at increased risk of sexually transmitted disease. Prev Med. 2016;88:86-9.
29. Lazarevich I, Irigoyen Camacho ME, Velazquez-Alva MDC, Zepeda Zepeda M. Relationship among obesity, depression, and emotional eating in young adults. Appetite. 2016;107:639–44.
30. Puccio F, Fuller-Tyszkiewicz M, Youssef G, Mitchell S, Byrne M, Allen N, et al. Longitudinal Bi-directional Effects of Disordered Eating, Depression and Anxiety. European eating disorders review: the journal of the Eating Disorders Association. 2017;25(5):351–8. 31. Schulz A, Northridge ME. Social determinants of health: implications for environmental health promotion. Health Education & Behavior. 2004;31(4):455–71.
32. Ramachandran A, Mary S, Yamuna A, Murugesan N, Snehalatha C. High prevalence of diabetes and cardiovascular risk factors associated with urbanization in India. Diabetes care. 2008;31(5):893–8.
33. Chen J, Chen S, Landry PF. Migration, environmental hazards, and health outcomes in China. Social Science & Medicine. 2013;80:85–95.
34. Bakar C, Oymak S, Maral I. Turkey's Epidemiological and Demographic Transitions: 1931-2013. Balkan medical journal. 2017;34(4):323–34.
35. Sen G, Gungor E, Sevik H. Defining the effects of urban expansion on land use/cover change: a case study in Kastamonu, Turkey. Environmental monitoring and assessment. 2018;190(8):454.
36. Beam CR, Emery RE, Reynolds CA, Gatz M, Turkheimer E, Pedersen NL. Widowhood and the stability of late life depressive symptomatology in the Swedish adoption twin study of aging. Behavior genetics. 2016;46(1):100-–3.
37. Sikorski C, Luppa M, Heser K, Ernst A, Lange C, Werle J, et al. The role of spousal loss in the development of depressive symptoms in the elderly—implications for diagnostic systems. Journal of affective disorders. 2014;161:97–103.

38. Fried EI, Bockting C, Arjadi R, Borsboom D, Amshoff M, Cramer AO, et al. From loss to loneliness: The relationship between bereavement and depressive symptoms. Journal of abnormal psychology. 2015;124(2):256.
39. Brown GW, Harris T. Social origins of depression: A study of psychiatric disorder in women: Routledge; 2012.
40. Kessler RC, Berglund P, Demler O, Jin R, Koretz D, Merikangas KR, et al. The epidemiology of major depressive disorder: results from the National Comorbidity Survey Replication (NCS-R). Jama. 2003;289(23):3095–105.
41. Treisman GJ, Angelino AF, Hutton HE. Psychiatric issues in the management of patients with HIV infection. Jama. 2001;286(22):2857–64.
42. Kim HY, Park M, Lee E. A cross-sectional survey of relationships between sexual knowledge, sexual attitudes, and reproductive health behaviour among female university students. Contemporary nurse. 2018;54(6):640–50.
43. Setyowati, Rizkia M, Ungsianik T. Improving Female Adolescents' Knowledge, Emotional Response, and Attitude toward Menarche following Implementation of Menarcheal Preparation Reproductive Health Education. Asian/Pacific Island nursing journal. 2019;4(2):84–91.
44. Darabi F, Yaseri M, Kaveh MH, Khalajabadi Farahani F, Majlessi F, Shojaeizadeh D. The Effect of a Theory of Planned Behavior-based Educational Intervention on Sexual and Reproductive Health in Iranian Adolescent Girls: A Randomized Controlled Trial. Journal of research in health sciences. 2017;17(4):e00400.

# Military Medicine Capabilities in the Australian Defence Force

*Commander N Westphalen*

## Introduction

This article is the latest of a series regarding the role of occupational and environmental medicine in the Australian Defence Force (ADF).[1,2,3,4,5,6,7]

These articles, as well as a recent Productivity Commission inquiry,[8] indicate that high workplace illness and injury rates confirm the need to improve the management of hazards associated with ADF workplaces with better emphasis on prevention. To this end, a submission by the Royal Australasian College of Physicians to the aforementioned inquiry advocated this would best be achieved by basing the ADF's health services on a systems-based occupational health strategic model.[9]

Doing so would have to entail reassessing the fundamental inputs to capability[10] for both Joint Health Command and Defence's Work Health and Safety Branch. The current state of the ADF's occupational and environmental health services, and the small number of specialist practitioners within the Australasian Faculty of Occupational and Environmental Medicine, suggest that a mature model would take 10–15 years' sustained effort.[11]

This article expands on these papers with respect to military medicine support for ADF operational capabilities, such as combat aircraft (including fixed-wing transport aircraft and helicopters), Joint Battlespace Aircraft Controllers (JBACs), military parachuting and diving and submarines. A previous paper has described the ADF's current military medicine capabilities to support operations in Chemical, Biological, Radiological and Nuclear (CBRN) environments.[12]

## Overview

Table 1 lists the ADF populations that require dedicated health support, based on their medical Specialist Employment Classifications (SPECs).[13]

Table 1 indicates that:

- 12.1 per cent of all ADF members have a SPEC. This proportion is equivalent to half of all Navy and Air Force members (24.4 per cent each) and a quarter of all Army members (51.2 per cent).
- 38.4 per cent of all ADF SPEC personnel are Air Force and constitute 19.1 per cent of all Air Force members. Not surprisingly, 82.7 per cent of Air Force SPEC members are aircrew, which increases to 97.1 per cent if JBACs are included.
- 35.0 per cent of all ADF SPEC personnel are Navy and constitute 17.4 per cent of all Navy members. These are distributed mostly between aircrew (22.0 per cent), divers (31.1 per cent) and submariners (41.5 per cent).
- The remaining 26.7 per cent of the ADF's SPEC personnel are Army and constitute only 6.3 per cent of all Army members. Army SPEC members mostly comprise aircrew (35.1 per cent) and parachutists (33.7 per cent).

**Table 1: ADF Population Requiring Dedicated Military Medicine Support as of 01 March 2019[1]**

| | Aircrew | JBACs | Divers2 | Paras | SM'ers3 | All SPEC Pers | Non-SPEC Pers | Total |
|---|---|---|---|---|---|---|---|---|
| **Navy** | 553 | 123 | 781 | 11 | 1,042 | 2,510 | 11,946 | 14,456 |
| **Army** | 673 | 274 | 302 | 646 | 18 | 1,913 | 28,458 | 30,371 |
| **RAAF** | 2,279 | 397 | 9 | 69 | 1 | 2,755 | 11,696 | 14,451 |
| **Total** | 3,505 | 794 | 1,092 | 726 | 1,061 | 7,178 | 52,100 | 59,278 |

## Health support for aviation operations

The Air Force's *Air Power Manual* indicates that ADF aviation capabilities include the following roles:

- Control of the air, through offensive and defensive counter-air operations.
- Strike operations, including strategic attack, close air support, air interdiction, maritime anti-surface warfare, anti-submarine warfare, electronic warfare and information operations.
- Air mobility operations, including air logistic support, airborne (including parachute) operations, air-to-air refuelling and aeromedical evacuation.
- Intelligence, surveillance and reconnaissance operations.[14]

All three Services contribute to these roles, using a combination of fixed (Air Force) and rotary-wing (Navy and Army) aircraft, including an increasing number of Unmanned Aerial Vehicles (UAVs).

It is a well-known adage that 'Aviation is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity or neglect'.[15] This reflects the interactions between the personnel who fly and otherwise operate or maintain aircraft and the physical and physiological hazards of the aviation environment, such as:

- reduced barometric pressure
- hypoxia
- acceleration forces associated with aircraft manoeuvring ('pulling G'), ejection and ground impact
- noise and vibration
- temperature extremes
- human factors, including ergonomics, sleep and fatigue
- escape (including ejection, ditching and underwater escape), survival and evasion.[16]

To this end, aviation medicine has enhanced flying safety since WWI.[17,18] However, unlike civilian aviators, ADF aircrew have an operational imperative to function *at the edge of their physiological and other limits as a matter of routine*, for example, fast jet aircrew who can pull more 'g' than their opponents have a substantial dogfighting capability edge. The ensuing risks should not be underestimated.[19,20,21,22,23]

The scope of *military* aviation medicine, therefore, includes enabling, sustaining and enhancing the performance of personnel engaged in *combat-related* flight operations. Historical examples include the development of 'g' suits for fast jet aircrew,[24] night vision aids to enhance fixed- and rotary-wing combat capability[25] and 'piddle-packs' for female aircrew.[26]

ADF aircrew have specific health standards that reflect the demands of the military aviation environment, for example, the importance of visual tasks for aircrew means that, compared with other occupations, they require a higher visual standard.[27] Aircrew recruiting health assessments are therefore used to reduce the risk of wasting training resources on entrants who are not medically suitable, while annual aircrew health assessments are subsequently used to monitor their ongoing suitability for aviation duties.

Even in the civilian setting, the scope of aviation medicine extends to the health, safety and working environments of the ground and seagoing personnel who support aviation operations.[28] It therefore, directly and indirectly includes all Air Force personnel and all Navy and Army personnel engaged in aviation-related occupations, including JBACs and UAV operators. Its relevance to parachutists not only pertains to assessing their medical suitability, but also addressing the physiological hazards associated with High Altitude High Opening (HAHO) and High Altitude Low Opening (HALO) operations.

The personnel who operate and maintain Air Force aircraft are typically home-based at Pearce WA, Tindall NT, Amberley QLD, Williamtown NSW, Richmond NSW, East Sale VIC and Edinburgh SA. Those for Army aircraft are home-based at Holsworthy NSW, Townsville QLD and Oakey QLD. While those for Navy aircraft are home-based at Nowra NSW.

However, in practice, non-deployed personnel with an aviation-related SPEC may be found at many other ADF bases throughout Australia. This poses significant challenges regarding their 'garrison' health services, particularly at bases that are not located near major urban centres.

Furthermore, ADF aviation medicine officers are often required to deploy with the aircrew they support. This creates tensions with respect to maintaining 'garrison' health services for non-deployed aircrew, both for extended deployments that require multiple aviation medicine personnel rotations, as well as multiple concurrent aviation medicine personnel deployments.

The Institute of Aviation Medicine (IAM) at RAAF Base Edinburgh acts as the ADF's centre of aviation medicine expertise. It provides a range of courses for Service and civilian health staff, while more advanced training necessitates sending selected medical officers on overseas courses in the US and UK. IAM also supports ADF aviation operations via research and policy development, using a very small number of uniformed and civilian personnel with diverse skills in aviation medicine, human factors and life support.[29] However, as the scope of IAM is limited to aircrew, it does not include the *non*-SPEC ADF members who support aviation operations or give its personnel a broader clinical grounding or currency *beyond* aviation medicine.

The IAM's policy development role supports the aviation medicine guidance per the *Defence Health Manual* website and the *Aviation Medicine for ADF Aircrew* manual.[30] In addition, Navy[31,32] and Army[33] both have their own operational and aviation medicine instructions that reflect their respective operational environments.

*Spatial Disorientation System trainer briefing, RAAF IAM, 2018*[34]

The scope of military aviation medicine is therefore far broader than simply providing primary care services for aircrew, JBACs and parachutists. It is, however, entirely consistent with a systems-based occupational health model.

## Health support for diving operations

Navy's diving capabilities are provided by Mine Clearance Divers (MCDs) and ship's divers. *Australian Maritime Doctrine* indicates that Navy Clearance Diving Teams (CDTs) assist with the identification and rendering safe of explosive devices, particularly in shallow water and in ports and harbours. They also conduct clandestine hydrographic surveys of beaches for amphibious operations and clear mines or obstacles. Other CDT elements conduct underwater battle damage repair and other support tasks involving the installation and repair of underwater fittings.[35]

Ship's divers provide part-time organic support for Fleet units with respect to hull searches, underwater engineering support and other tasks as required.[36] Army diving capabilities are provided by special forces divers and Army work divers. Special forces divers undertake a range of tactical operations, some of which can have strategic effects.[37] Army work divers *facilitate* tactical mobility for land operations, by reconnoitring wet gap crossings and bridges, clearing underwater obstacles and mines, supporting wet gap crossings and removing underwater battlefield hazards. They also *restrict* enemy mobility by emplacing underwater obstacles, enhancing natural obstacles and undertaking demolitions. They also provide diving support to emergency respondents for tasks such as firefighting and urban search and rescue. Other Army work diver tasks include underwater damage assessment, equipment searches and recovery, maintaining lines of communication and supporting engineering tasks.[38]

For the purpose of this article, the term 'diving medicine' refers to the aspect of military medicine that is concerned with the interactions between the personnel who dive (and those who support them) and the physical and physiological hazards of the diving environment, such as:

- increased barometric pressure
- abnormal gas pressures
- cold and hypothermia
- (near) drowning
- infections
- dangerous marine creatures
- human factors, including ergonomics, stress responses, panic and fatigue.

To this end, diving medicine has enabled diving safety for more than 150 years.[39,40] However, like aircrew, ADF divers also have an operational imperative to *function at the edge of their physiological and other limits as a matter of routine*, albeit on comparable terms as other occupational (as opposed to recreational) divers. For example, Navy's coastal minehunters can be equipped with recompression chambers for *operational* rather than therapeutic purposes, to extend diving durations and bottom times while preventing dysbaric diving illnesses such as decompression illness and barotrauma.[41] Even so, the risks should likewise not be underestimated.[42,43,44,45,46]

To this end, ADF divers have specific health standards that reflect the demands of the diving environment, in particular an absence of lung and ear abnormalities.[47] Unlike aircrew recruiting health assessments, the purpose of diver health assessments pertains less to enabling operational capability than to reduce the risk of death or serious injury for entrants who are not medically suitable. However, even despite these standards, diving medicine practitioners may still have to treat dysbaric diving illnesses, breathing gas toxicity and other diving-related clinical conditions.

The scope of diving medicine also comprises enabling, sustaining and enhancing the performance of personnel engaged in diving operations, such as developing or assessing the various types of open- and closed-circuit air, oxygen and mixed gas breathing sets. It also includes facilitating the health, safety and working environments of all ADF personnel who directly or indirectly undertake diving-related occupations, such as the medical and other personnel who undertake operational and/or therapeutic recompression chamber duties.

Navy's CDTs are based at HMAS *Waterhen* in Sydney NSW and HMAS *Stirling* in Perth WA, while the ADF Diving School is located at HMAS *Penguin* in Sydney. Ship's divers are assigned to all Fleet units, which are generally homeported at HMA Ships *Kuttabul* and *Waterhen* in Sydney, HMAS *Coonawarra* in Darwin NT, and HMA Ships *Cairns* and *Stirling*. Army divers are located at various special forces and engineering units based throughout Australia.

Like aircrew, however, non-deployed ADF divers can be found at many other bases Australia-wide. As Navy divers, in particular, may be posted to sea at short notice, those so liable are required to maintain their medical suitability for diving duties at all times. This likewise poses challenges with providing their 'garrison' health services, especially at bases that are not located near major urban centres. Key mitigation, however, is that unlike the aviation setting, health support for deployed and non-deployed ADF diving operations are usually conducted by specially trained diving medicine medics, albeit *without* direct medical officer supervision. Besides maintaining their clientele's medical suitability for deployed diving duties, these medics may also be required to provide emergency hyperbaric and other treatment for diving casualties.

The ADF's centre of diving medicine expertise is the Submarine and Underwater Medicine Unit–East (SUMU-E) at HMAS *Penguin* in Sydney NSW. Like IAM, it is staffed by a limited number of uniformed and civilian personnel with a diverse range of skills. Unlike IAM, which has no direct clinical role, SUMU-E also provides primary care services for the co-located ADF Diving School, in conjunction with recently co-located *Penguin* garrison health staff.

SUMU-E also provides diving medicine-related courses for all Navy medical officers and other ADF and civilian health staff. At present, there is no requirement for overseas diving medicine courses.

Finally, SUMU-E undertakes a range of research and policy development activities. The latter includes the diving medicine guidance in Australian Book of Reference (ABR) 155 *RAN Diving Manual*,[48] entry medical standards for divers and submariners per the *Defence Health Manual*[49] and ABR 1991 *RAN Health Service Manual* Chapter 7.[50] Army work divers and special forces divers also have their own references.[51,52]

*Opening Ceremony, SUMU-E, HMAS* Penguin, *09 Dec 13*[53]

The scope of military diving medicine, therefore, extends considerably beyond simply providing primary care services for ADF divers. Like aviation medicine, however, it is also consistent with a systems-based occupational health model.

## Health support for submarine operations

*Australian Maritime Doctrine* states that, with their inherent stealth, long-range endurance, striking power and intelligence gathering capabilities, submarines can have a significant impact on high-level maritime warfare.[54] To this end, Navy presently operates six *Collins* class submarines,[55] to be replaced by 12 *Attack*-class submarines from the early 2030s.[56]

For the purpose of this article, the term 'submarine medicine' refers to that aspect of military medicine that is concerned with submarine operations. This includes (but is not limited to) those associated with:

- shipboard occupational and environmental hazards that are associated with surface vessels, as well as those that are intrinsic to submarines[57]
- shipboard emergencies, such as fire, flooding and toxic hazards. Limited buoyancy compared to surface ships and limitations on the crew's ability to abandon ship pose additional threats even when surfaced
- waiting for rescue in the event of a survivable submarine accident. These hazards include toxic and/or hyperbaric atmospheres, cold and hypothermia, and dehydration and hunger. Rescue can be achieved using a suitable rescue vehicle[58,59]
- diving hazards (in particular drowning, ear and lung trauma and exposure) in the event of having to escape from a disabled submarine, if survivors are unable to wait for rescue.

The risks posed by these hazards are substantial.[60,61,62,63,64,65,66] However, unlike aviation and diving medicine, the requirement for dedicated submarine medicine health support stems less from the risks of routinely operating non-nuclear submarines at their maximum level of performance, than from their limited organic health support, continuous exposure to a range of workplace health hazards for months at a time, and saving lives *in extremis* in the event of a survivable submarine accident.

The latter requirement drives the entry and periodic health standards for Navy submariners.[67,68] To this end, all RAN submariners undertook Pressurised Submarine Escape Training (PSET) in the UK from the mid-1960s until 1989, when it was repatriated to the Submarine Escape Training Facility (SETF) at HMAS *Stirling*, until its cessation in September 2018.[69] During that time, SETF medical staff treated more than 300 diving casualties (including 29 requiring recompression), from about 4000 students and staff who collectively performed over 140 000 ascents.[70]

An additional complication pertains to the requirement to provide health support for Navy's submarine abandonment, escape and rescue (SAER) capability, in the form of deployable on-scene emergency hyperbaric and trauma treatment services. This capability is required to be rapidly deployable to survivable depths anywhere within Australia's area of direct security interest, which encompasses up to 10 per cent (51 million km$^2$) of the Earth's surface.[71]

While Navy's SAER capability uses a combination of ADF and contract civilian assets, the deployed health support services themselves are almost exclusively a Navy responsibility. This is because the civilian health sector cannot deploy emergency hyperbaric and trauma treatment services that can treat up to 60 submarine accident survivors at an accident scene. While this capability has not yet deployed for an actual submarine accident, it is exercised annually.[72]

*Submarine Intervention Gear Ship MV* Besant[73] *and HMAS* Rankin,[74] *Exercise BLACK CARILLON, 2015*[75]

Unlike surface Fleet units, submarines do not have a medical officer embarked, relying instead on submariner-qualified medical sailors, whose primary role is to maintain operational capability by reducing the need to land sick or injured crewmembers while deployed. This means that although these sailors have the same medical training as their surface counterparts, workload considerations mean their duties as medics are normally secondary to those as submariners.

While all submarines are homeported at HMAS *Stirling*, submariners can be found at any Navy shore establishment and many other ADF bases throughout Australia. Like divers, those with a liability to go to sea at short notice again pose particular challenges with providing their 'garrison' health services, in particular ensuring their medical suitability for submarine duties among a plethora of other submariner personnel management issues.[76]

Until recently, the ADF's centre of submarine medicine expertise was provided by the Submarine and Underwater Medicine Unit–West (SUMU-W) at HMAS *Stirling*, which is subordinate to the Officer-In-Charge at SUMU-E. At present, at least one SUMU-W medical officer is required to have undertaken the Canadian Forces submarine medicine course.[77]

SUMU-W was established in 2000, to provide dedicated underwater medicine services for all submariners and divers at *Stirling*. Besides giving SETF medical staff clinical work to do while covering PSET (thereby also reducing the *Stirling* sickbay workload), this replicated the dedicated submariner health services that had been provided at the submarine base at HMAS *Platypus* in Sydney, from 1967 until its closure in 1999.

Since the cessation of PSET, and of providing dedicated primary care services for submariners and divers, SUMU-W now only conducts *non*-pressurised submarine escape and rescue medical training, as well as a limited range of submarine-related research and policy development activities as directed by the Officer-In-Charge SUMU-E. Examples of the former include potable water contamination and submarine atmospheric standards; the latter includes providing medical advice regarding the aforementioned submarine recruiting medical standards,[78] as well as SAER medical guidance for Australian Fleet Tactical Publication 9(H) *Australian Submarine Search and Rescue Instructions*[79] and other related references.

*Submarine Escape Training Facility (now the Submarine Escape and Rescue Centre), HMAS* Stirling, *1998*[80]

Once again, the scope of submarine medicine is consistent with a systems-based occupational health model. The splitting of primary care from the other submarine medicine services at *Stirling*, therefore, constitutes a retrograde step, whose impact on submarine operational capability remains to be seen. Examples of the latter include ensuring submariner seagoing medical suitability *beyond* providing their primary health care[81,82] and identifying future submarine workplace health hazards.[83]

## Implications

Some of the ADF's more specialised operational capabilities require over 7000 of its permanent members to have a SPEC. This number is surprisingly large — it is equivalent to *half* of all Navy and Air Force and a *quarter* of all Army members.

These members are not evenly distributed: 15–20 per cent of all Air Force and Navy members have a SPEC, compared to only about five per cent of Army members. Neither are these members evenly distributed: while the majority are aviation-related (if one adds JBACs and perhaps parachutists), about 75 per cent of Navy SPEC members are either divers or submariners.

These proportions are substantially increased by the *non*-SPEC ADF personnel who *indirectly* support the operations conducted by SPEC members. They include most if not all Air Force, a significant proportion of Navy and a smaller proportion of Army members. An added complication to providing health services for SPEC personnel is that they can all be found more-or-less at any ADF base within Australia.

These personnel require bespoke health services because what they need is not generally available in civilian medical practice in forms that meet ADF operational requirements. This particularly refers to (as examples):

- enabling their ability to function at their physiological limits to give them a capability edge (aircrew and divers)
- sustaining these capabilities via deployable health services (aircrew and divers). This also includes providing bespoke (hyperbaric) treatment services for single (diver) or multiple (submariner) casualties.

It is therefore unclear how the ADF's current health delivery model enables operational capabilities that require SPEC personnel. As the necessary skills are (by definition) not generally available in civilian practice, ab initio civilian 'garrison' health staff require additional training and mentoring support. However, their frequently itinerant employment as contractor employees either limits or precludes them from undertaking this training; alternatively, such training is lost if (or when) they move on from working for Defence. At the same time, uniformed medical officer recruiting and retention issues have led to hollowness and fragility in medical SPEC expertise — all three Services lack long-service uniformed aviation medicine practitioners, while only two Navy medical officers have remained in the Permanent Navy beyond their posting as OIC SUMU-East since 2006.[84]

Hence at present, clinical SPEC health services are generally provided by junior uniformed medical officers of high turnover and limited experience and a very small pool of typically ex-ADF civilian contract and APS staff. Besides the ensuing lack of *clinical* SPEC medical experience, the inability to retain uniformed aviation and underwater medical officers is having adverse effects on ADF operational capability concerning its *non*-treatment-service-oriented military health functions of SPEC research, training, policy development, medical suitability assessments and (in particular) workplace health hazards.

Hence, the scope of SPEC health services *must* be far broader that simply providing primary care and other treatment services. In order to also address their *non*-clinical operational requirements, the health services for *each* of these SPECs can and should be considered bespoke exemplars of military occupational and environmental medicine.[85]

Yet, at the same time, the limited size of the SPEC health services precludes them from operating in isolation from the ADF's *non*-SPEC health services, especially regarding those members who *indirectly* support the ADF's SPEC capabilities. This limits (but does not exclude) proposals such a 'blended career model', whereby uniformed medical officers transition to APS/contracted positions while remaining reservists, so they can pursue a (typically clinical-only) specialisation in a particular SPEC. Although such a model may be attractive from an *individual career perspective*, it is unclear how it enables *actual ADF operational* capability, especially for bases that are not located near major urban centres.

Rather, the support required by the SPEC health services of the ADF's health services (and vice versa) can and should be achieved via a holistic, systems-based, occupational health strategic model.

## Conclusion

With ADF personnel arguably exposed to the most diverse range of occupational and environmental hazards of any Australian workforce, high rates of preventable workplace illness and injury indicate the need to improve the management of occupational and environmental health hazards, with better emphasis on prevention than treatment.

This suggests the need for substantially revised fundamental inputs to ADF health capability to develop a genuinely holistic and sustainable systems-based occupational health strategic model. Among its other attributes, the proposed model would incorporate each of the bespoke health services for the ADF's SPEC personnel, as microcosms of a broader systems-based, occupational health strategic model that can enable overall ADF operational capability.

## Author

Dr Neil Westphalen graduated from Adelaide University in 1985 and joined the RAN in 1987. He is a RAN Staff Course graduate and a Fellow of the Royal Australian College of General Practitioners, the Australasian Faculty of Occupational and Environmental Medicine, and the Australasian College of Aerospace Medicine. He also holds a Diploma of Aviation Medicine and a Master of Public Health.

His seagoing service includes HMA Ships *Swan*, *Stalwart*, *Success*, *Sydney*, *Perth* and *Choules*. Deployments include DAMASK VII, RIMPAC 96, TANAGER, RELEX II, GEMSBOK, TALISMAN SABRE 07, RENDERSAFE 14, SEA RAIDER 15, KAKADU 16 and SEA HORIZON 17. His service ashore includes clinical roles at *Cerberus*, *Penguin*, *Kuttabul*, *Albatross* and *Stirling*, and staff positions as J07 (Director Health) at the then HQAST, Director Navy Occupational and Environmental Health, Director of Navy Health, Joint Health Command SO1 MEC Advisory and Review Services, and Fleet Medical Officer (2013-2016).

Commander Westphalen transferred to the Active Reserve in 2016. Comments regarding this and previous articles are most welcome.

## Disclaimer

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

*Corresponding Author: Neil Westphalen,*
*neil.westphalen@bigpond.com*
*Authors: N Westphalen[1,2]*
*Author Affiliations:*
*1 Royal Australian Navy Reserve*
*2 Navy Health Service, C/O Director Navy Health*

## References

1 Westphalen N, Occupational and environmental medicine in the Australian Defence Force, Aust Def Force J, Nov/Dec 2016;200:49–58. Available from: http://www.defence.gov.au/ADC/ADFJ/Documents/issue_200/Westphalen_Nov_2016.pdf.

2 Westphalen N, Primary health care in the Australian Defence Force, Aust Def Force J, Jul/Aug 2017;202:91–7. Available from: http://www.defence.gov.au/adc/adfj/Documents/issue_202/Westphalen_July_2017.pdf.

3 Heslop DJ, Westphalen N. Medical CBRN Defence in the Australian Defence Force, JMVH. Jan 2019;27(1):66–73. Available from https://jmvh.org/wp-content/uploads/2019/01/AMMA-JMVH-Jan-2019-compressed-1.pdf.

4 Westphalen, N, Assessing medical suitability for employment and deployment in the Australian Defence Force, Aust Def Force J, Jan 2018;203:67–74. Available from: http://www.defence.gov.au/adc/adfj/Documents/issue_203/ADF per cent20Journal per cent20203_Article_Westphalen.pdf.

5 Westphalen N. Compensation in the Australian Defence Force, JMVH, Jan 2019;27(1):58–65. Available from: https://jmvh.org/wp-content/uploads/2019/01/Compensation-in-the-Australian-Defence-Force.pdf.

6 Westphalen N. Rehabilitation in the Australian Defence Force, JMVH, Oct 2019;27(4):7–14. Available from: https://jmvh.org/wp-content/uploads/2019/10/AMMA-JMVH-October-2019.pdf.

7 Westphalen N. Casualty Evacuation in the Australian Defence Force, JMVH, Jan 2020;28(1):29–38. Available from: https://jmvh.org/wp-content/uploads/2020/04/AMMA-JMVH-Jan-2020_print.pdf

8 Productivity Commission, Overview: A better way to support veterans and their families, Jul 2019. Available from: https://www.pc.gov.au/inquiries/completed/veterans/report/veterans-overview.pdf. It is essential to note this report uses the term 'veteran' to refer to current as well as ex-serving ADF members.

9 Productivity Commission, RACP submission to the draft Productivity Commission report: A Better Way to Support Veteran, Feb 2019. Available from: https://www.pc.gov.au/__data/assets/pdf_file/0003/236811/subdr234-veterans.pdf.

Disclaimer: the author was requested to draft this submission, as a member of the AFOEM Policy and Advocacy Committee (PAC). It was cleared by both the Faculty and College PACs prior to submission.

10 Department of Defence, Defence Capability Development Handbook, 2012. Available from: http://www.defence.gov.au/publications/DefenceCapabilityDevelopmentHandbook2012.pdf.

This reference describes the following fundamental inputs to (in this case health) capability (FiCs).

Personnel;
Organisation;
Collective training;
Facilities;
Supplies;
Major systems;
Support, and
Command and management.

11 Royal Australasian College of Physicians, Occupational and Environmental Medicine. Available from: https://www.racp.edu.au/trainees/advanced-training/advanced-training-programs/occupational-and-environmental-medicine.

12 Heslop DJ, Westphalen N. Medical CBRN Defence in the Australian Defence Force, JMVH, Jan 2019;27(1):66–73. Available from: https://jmvh.org/wp-content/uploads/2019/01/Medical-CBRN-Defence-in-the-Australian-Defence-Force.pdf.

13 ADF Military Personnel Manual (MILPERSMAN), Part 3, Chapter 2 Australian Defence Force Medical Employment Classification (MEC) System (only available on the Defence Intranet).

14 Air Force Headquarters, Australian Air Publication AAP 1000–D The Air Power Manual (6th ed), September 2013. Available from: http://airpower.airforce.gov.au/APDC/media/PDF-Files/Doctrine/AAP1000-D-The-Air-Power-Manual-6th-Edition.pdf.

15 Global Aerospace, History. Available from: http://www.global-aero.com/about/history.

16 Gradwell, David P, Rainford, David J. Ernsting's Aviation and Space Medicine (5th ed), CRC Press, Taylor and Francis Group; Boca Raton Florida USA, 2016.

17 For a history of aviation medicine, see Peyton G. 50 Years of Aerospace Medicine 1918–1968. United States Air Force School of Aerospace Medicine, AFSC Historical Publications Series no. 67–180, 1968.

18 Using the US Navy as an example of how military aircraft mishap rates have been reduced since the 1950s, see Dunn, Robert F. Gear Up, Mishaps Down, Chapter 10. Naval Institute Press, Annapolis Maryland USA, 2017.

19 Directorate of Defence Aviation and Air Force Safety Sifting through the evidence: RAAF F-111 And AF/A-18 aircraft and crew losses. Available from: http://www.pigzbum.com/accidents/sifting-through-the-evidenc.pdf.

20 Aviation Safety Network, 29 October 1991, Boeing 707-368C, RAAF. Available from: https://aviation-safety.net/database/record.php?id=19911029-0.

21 Department of Defence, Royal Australian Navy Nias Island Sea King accident, Board of Inquiry Report Executive Summary. Available from http://www.defence.gov.au/Publications/BOI/SeaKing/pdf/chapters/EXECUTIVE per cent20Summary.pdf.

22 Department of Defence, Chief of Defence Force Blackhawk 221 Board of Inquiry 2007–2008. Available at http://www.defence.gov.au/publications/coi/reports/bh221_boi_report.pdf.

23 Roberts K, Clark G, The 1996 Black Hawk accident: the technical investigation. Available from: https://www.researchgate.net/publication/281061492_The_1996_Black_Hawk_Accident_-_The_Technical_Investigation.

24 Wood EH, Lambert EH. The effect of anti-blackout suits on blood pressure changes produced on the human centrifuge. Federation Proceedings, 1946;5(1)Pt 2:115.

25 TopOwl® - designed by pilots, for pilots. Helmet Mounted Sight Display for helicopters, Thales. Available from: https://www.thalesgroup.com/en/worldwide/defence/topowlr-helmet-mounted-sight-and-display-helicopters.

26 Smart TL. Postscript to Chapter 3: Fast Women in the 21st Century, in Absent Aviators: Gender issues in aviation, Bridges D, Neal-Smith J, (eds). Available from: https://books.google.com.au/books?id=te6_CwAAQBAJ&pg=PT105&dq=aircrew+piddle+pack+female&hl=en&sa=X&ved=0ahUKEwjP0Ij8yLnTAhXGf7wKHdciD4MQ6AEIIzAA#v=onepage&q=aircrew per cent20piddle per cent20pack per cent20female&f=false.

27 DHM Volume 2 Part 5 Chapter 7 Health Requirements for Aviation-Related Occupations (only available on Defence intranet).

28 For what is probably the most egregious recent ADF example when this requirement was not met, see Clarkson JW, Hopkins WA, and Taylor KV. 'Chemical exposure of Air Force maintenance workers: report of the Board of Inquiry into F-111 (fuel tank) deseal/reseal and spray seal programs', 2001 29 Jun, Canberra: Air Force Headquarters.

29 'Health service profile: Institute of Aviation Medicine', ADF Health Journal, 1999;1(1):back page.

30 Aviation Medicine for ADF Aircrew (3rd ed) AL6 (only available on Defence intranet).

31 ABR 5150 RAN Aviation Instructions (only available on Defence intranet, being revised).

32 ABR 1991 RAN Health Service Manual (only available on Defence intranet, being revised).

33 Army Standing Instructions (Aviation) Operations Part 6 Flying Safety and Aviation Medicine (only available on Defence intranet).

34 Department of Defence image gallery, 20181005raaf8485160_007. Available from: https://images.defence.gov.au/assets/archives/5003-All-Defence-Imagery/?q=20181005raaf8485160_007.

35 Australian Maritime Doctrine. Available from: http://www.navy.gov.au/sites/default/files/documents/Amd2010.pdf.

36 ABR 155 RAN Diving Manual (only available on Defence intranet, being revised).

37 Land Warfare Procedures – Special Operations Forces 9-3-14 Tactical Diving (only available on Defence intranet).

38 Land Warfare Procedures – Combat Arms (Engineer) 2-8-1 (only available on Defence intranet).

39 Acott S, The diving "law-ers": a brief resume of their lives, SPUMS Journal, March 1999;29(1):39–42. Available from: http://archive.rubicon-foundation.org/xmlui/bitstream/handle/123456789/5990/SPUMS_V29N1_10.pdf?sequence=1.

40 Acott S. JS Haldane, L Hill and A Siebe: a brief resume of their lives, SPUMS Journal, 29(3):161–165. Available from: http://archive.rubicon-foundation.org/xmlui/bitstream/handle/123456789/6016/SPUMS_V29N3_9.pdf?sequence=1.

41 [Australian] Navy: Serving Australia with Pride, Minehunter Coastal (MHC). Available from: http://www.navy.gov.au/fleet/ships-boats-craft/mhc.

42 Warren CET, Benson J. Above Us the Waves: The Story of Midget Submarines and Human Torpedoes. George G Harrap and CO, London, 1953.

43 Bailey J. The White Divers of Broome: The True Story of a Fatal Experiment. Pan Macmillan, Sydney, 2001.

44 Salmon G. Navy Divers: The Incredible Story of the Australian Navy's Elite Unit. Random House Australia, 2011; also Linton EW, Donohue HJ. United and Undaunted – the First 100 Years. Grinkle Press, 2015.

45 Thalmann ED, Decompression illness: what is it and what is the treatment?, Diver's Alert Network. Available from: http://www.diversalertnetwork.org/medical/articles/Decompression_Illness_What_Is_It_and_What_Is_The_Treatment.

46 De Gelder P. No Time for Fear: How a Shark Attack Survivor Beat the Odds, Penguin Books Australia, 2013.

47 DHM Volume 2 Part 5 Chapter 8 Health Requirements for Divers (only available on Defence intranet).

48 ABR 155 RAN Diving Manual (only available on Defence intranet, being revised).

49 DHM Volume 1 Part 5 Chapter 8 (divers) and Chapter 9 (submariners) (only available on Defence intranet).

50 ABR 1991 RAN Health Services Manual Chapter 7 Health Assessments for the Maritime Environment (only available on Defence intranet). This reference was rewritten in 2015, and has since awaited promulgation.

51 Land Warfare Procedures – Combat Arms (Engineer) 2-8-1 (only available on Defence intranet).

52 Land Warfare Procedures – Special Operations Forces 9-3-14 Tactical Diving (only available on Defence intranet).

53 Department of Defence image gallery, 20131209ran8531447_013. Available from: https://images.defence.gov.au/assets/archives/5003-All-Defence-Imagery/?q=20131209ran8531447_013.

54 Australian Maritime Doctrine. Available from: http://www.navy.gov.au/sites/default/files/documents/Amd2010.pdf.

55 [Australian] Navy: Serving Australia with Pride, Guided Missile Submarine, Diesel-Electric (SSG), available from: http://www.navy.gov.au/fleet/ships-boats-craft/submarines/ssg

56 [Australian] Navy: Serving Australia with Pride, Attack Class SSG. Available from: http://www.navy.gov.au/fleet/ships-boats-craft/future/ssg.

57 Westphalen N, Occupational and environmental medicine in the Australian Defence Force, Aust Def Force J, Nov/Dec 2016;200:49–58. Available from: http://www.defence.gov.au/ADC/ADFJ/Documents/issue_200/Westphalen_Nov_2016.pdf.

58 [Australian] Navy: Serving Australia with Pride, Submarine Rescue Vehicles – LR5. Available from: http://www.navy.gov.au/fleet/ships-boats-craft/submarines/submarine-rescue-vehicles.

59 America's Navy: forged by the sea, Submarine Rescue Diving and Recompression System (SRDRS). Available from: https://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=400&ct=4.

60 Maas P. The Terrible Hours: The Epic Rescue of Men Trapped Beneath the Sea. Harper Collins, New York, 1999.

61 Gray E. Few Survived: A History of Submarine Disasters. Leo Cooper, London, 1986.

62 Warren CET, Benson J. The Story of His Majesty's Submarine 'Thetis' and 'Thunderbolt'. George G, Harrap, London, 1958.

63 Submarine Force Museum: home of historic ship Nautilus, The Loss of USS Thresher (SSN-593). Available from: https://ussnautilus.org/blog/the-loss-of-uss-thresher-ssn-593.

64 Harvey C, Carson J. The B.A.P. Pacocha (SS-48) Collision: The Escape and Medical Recompression Treatment of Survivors, [US] Naval Submarine Medical Research Laboratory. Available from: https://apps.dtic.mil/dtic/tr/fulltext/u2/b132723.pdf.

65 Mizokami K, In 2005, a U.S. Navy submarine ran into a mountain, Popular Mechanics, 06 December 2016. Available from: https://thenewsrep.com/69355/2005-u-s-navy-submarine-ran-mountain.

66 BBC News, Argentina missing sub: Congress commission to investigate, 15 January 2018. Available from: https://www.bbc.com/news/world-latin-america-42689310.

67 DHM Volume 2 Part 5 Chapter 9 Health Requirements for Submariners (only available on Defence intranet).

68 Davison, J, Allibone, T. Beneath Southern Seas: The Silent Service. University of Western Australia Press, 2005.

69 SETF was renamed the Submarine Escape and Rescue Centre (SERC) sometime before 2004.

70 SUMU-W PSET records (only available on Defence Intranet).

71 Australian Maritime Doctrine. Available from: http://www.navy.gov.au/sites/default/files/documents/Amd2010.pdf.

72 Naval Today.com, Australian Navy hones submarine rescue skills during Black Carillon. Available from: https://navaltoday.com/2016/09/14/australian-navy-hones-submarine-rescue-skills-during-black-carillon.

73 [Australian] Navy: Serving Australia with Pride, MV Besant, available from http://www.navy.gov.au/mv-besant. Her sister MV Stoker is Navy's Submarine Rescue Gear Ship; see Australian] Navy: Serving Australia with Pride, MV Stoker. Available from: http://www.navy.gov.au/mv-stoker.

74 [Australian] Navy: Serving Australia with Pride, HMAS Rankin. Available from: http://www.navy.gov.au/hmas-rankin.

75 Department of Defence image gallery, 20151009ran8526162_100. Available from: https://images.defence.gov.au/assets/archives/5003-All-Defence-Imagery/?q=20151009ran8526162_100.

76 Harrap J, Reflections of a Collins Submarine Captain, Asia-Pacific Defence Reporter, 04 May 2012. Available from: https://asiapacificdefencereporter.com/reflections-of-a-collins-submarine-captain.

77 Worldwide Military Medicine.com, Almanac: Canada. Available from: https://military-medicine.com/almanac/30-canada.html.

78 DHM Volume 2 Part 5 Chapter 9 Health Requirements for Submariners (only available on Defence intranet)

79 Australian Fleet Tactical Publication 9(H) Australian Submarine Search and Rescue Instructions (only available on Defence intranet).

80 Department of Defence image gallery, mis98185-14. Available from: https://images.defence.gov.au/assets/archives/5003-All-Defence-Imagery/?q=mis98185-14%E2%80%99.

81 Westphalen N, Assessing medical suitability for employment and deployment in the Australian Defence Force', Aust Def Force J, Jan 2018;203:67–74. Available from: http://www.defence.gov.au/adc/adfj/Documents/issue_203/ADF per cent20Journal per cent20203_Article_Westphalen.pdf.

82 Westphalen N. Enabling Operational Capability: Elements of an Australian Maritime Health Doctrine and Why Navy Needs One. Australian Naval Institute Occasional Paper No 1, May 2019 pp. 15–16. Available from: https://navalinstitute.com.au/wp-content/uploads/ANI-Maritime-Health-Doctrine.pdf. In short, this reference suggests the extent to which a significant proportion of general service (i.e. non-SPEC) Navy members may be being made unfit for sea unnecessarily.

83 See Clarkson JW, Hopkins WA and Taylor KV. Chemical exposure of Air Force maintenance workers: report of the Board of Inquiry into F-111 (fuel tank) deseal/reseal and spray seal programs, 2001 29 Jun, Canberra: Air Force Headquarters. It is understood that the hazards posed by the F-111 deseal/reseal program in 2000, were first acted upon by an occupational physician rather than a GP.

84 SUMU-East honour board refers.

85 Westphalen N, Occupational and environmental medicine in the Australian Defence Force, Aust Def Force J, Nov/Dec 2016;200:49–58. Available from: http://www.defence.gov.au/ADC/ADFJ/Documents/issue_200/Westphalen_Nov_2016.pdf.

# The Prevalence of Prostate, Urinary Bladder and Kidney Cancer among the Homeland War Veterans

*T Sorić, I Gusar, A Zekanović, I Vidić, B Dželalija*

## Introduction

Relevant literature mentions exposure to war events as a significant factor in the emergence of not only mental but also physical illnesses.[1–3] Enormous effort is being put into finding new and better ways of treatment while, at the same time, efforts are expended on the development and acquisition of weapons and other material that could cause disease and adverse health outcomes. The Homeland War in the Republic of Croatia was fought between 1990 and 1995, and it is estimated that over 500 000 soldiers fought in the war.[4,5] Croatian defenders can unquestionably be singled out as a particularly vulnerable group due to long-term and serious consequences of war-related sufferings.[6] The available data in Zagreb City Office for Health and War Veterans state malignant neoplasms as a leading cause of death among war veterans between 2006 and 2011.[6] Furthermore, the research on disease incidence and mortality of the general population conducted in Zadar County in 2005 puts malignant neoplasms in second place, just after leading cardiovascular diseases,[7] but the research on the veteran population is deficient. Wartime events always cause a large amount of stress[8–10] associated with the emergence of malignant neoplasms.[11] It is well-known that hormones such as cortisol, norepinephrine and adrenaline, which are released during stressful situations, change the immune status of the body and the ability to fight cancer.[12] Thus, psychological and neurophysiological occurrences in the body are crucial for immune system functioning or the ability of the body to efficiently cope with stressful situations.[12,13]

Many former studies have investigated the impact of stress on cancer emergence,[14–16] but there is a lack of research investigating the consequences of stress occurring during war and the impact of cancer on active war participants. Carcinoma is the leading cause of morbidity and mortality of people worldwide. Cancer incidence is a leading public health problem both in Croatia and worldwide, and the number of newly-discovered cases is constantly increasing.[17–19] Despite the implementation of primary prevention, which includes preventive measures, secondary prevention plays an important role. Specifically, secondary prevention implies early detection of cancer, which is achieved by actively looking for people affected by cancer amongst a seemingly healthy population.[20] This type of prevention includes adequate, highly sensitive and specific methods of screening, accessible and acceptable to a broader population.[20] In recent years, an increase in men affected with urogenital tract cancer has been noticed in Croatia.[19,21,22] Several studies show the occurrence of urogenital tract cancer among war veterans.[23–25] Therefore, this study aims to investigate the prevalence of prostate, bladder and kidney cancer among the Homeland War veterans of 50–70 years of age in relation to the general male population of the same age in the Republic of Croatia.

With regard to long-term exposure to war, we expect a more frequent prevalence of prostate, urinary bladder and kidney cancer among the Homeland War veterans compared to the general male population aged 50 to 70.

## Materials and methods

The cross-sectional study was conducted in Zadar General Hospital, Croatia in the period from 1 March 2017 to 30 June 2018 within the Preventive Physical Examination Program for Croatian Homeland War Veterans.[4]

### Participants

Of the 2101 Homeland War veterans that were processed, 1425 men were included in the research. They fulfilled the following criteria: participants in the Homeland War; participated in the war for more than 1500 days; aged 50–70; and had not previously received treatment for prostate, urinary bladder and kidney cancer.

All Homeland War veterans who met the set criteria were included in the research protocol, which implied: registration of the veterans in the County Office of War Veterans; acquainting the veterans with the implementation of the Preventive Physical Examination Program by the employees of the County Office of War Veterans; registration of veterans in a health institution; registration with the coordinator for the implementation of preventive examination programs in a health institution; informing the veterans on the content and implementation of preventive exams by the coordinator; giving consent and signing written consent / informational consent for the participation in the preventive examination program; giving consent and signing written consent / informational consent for the participation in the research.

### Variables

Diagnostic treatment of the subjects included: anamnesis; clinical testing; laboratory tests (prostate-specific antigen, (PSA) + routine blood parameters); ultrasound of the whole abdomen; and transabdominal ultrasound prostate examination. Diagnostic treatment of subjects with suspected prostate cancer in further treatment included prostate biopsy and histopathological examination of the sample.

Diagnostic treatment of subjects with suspected urinary bladder cancer included the use of multilayer computerised tomography (MSCT) and cystoscopy, as well as an endoscopic procedure during which the material for histopathological diagnosis was taken.

Diagnostic treatment of subjects with suspected kidney cancer included additional radiotherapy, MSCT and histopathological treatment of the preparations taken during surgery (nephrectomy, partial nephrectomy).

The control group in the study consisted of men aged 50 to 70, registered in the Bulletin of the Croatian Institute of Public Health 'Incidence of Cancer in Croatia'[21] suffering from prostate cancer, urinary bladder cancer and kidney cancer from the total population of men of the same age as recorded in the Central Bureau of Statistics.[26]

### Bias

The examined group represents only one part of the total number of Home War participants from one Croatian county. It is also possible that in addition to participating in the war, there were other risk factors for the onset of the disease among the subjects. This study could not provide data on causal relationship.

### Study size

The number of participants is defined by the number of respondents who are registered in the County Office and have accepted the invitation. The number was also influenced by the duration of the Preventive Physical Examination Program for Croatian Homeland War Veterans.

### Statistical analysis

The obtained data have been processed in the Windows Statistics Database (TIBCO Software Inc., 2017). During statistical data processing, the chi-square test ($\chi^2$ test) was used to determine whether the received (observed) frequencies deviated from the expected frequencies. In our study, the observed frequencies of the selected diagnoses on the sample veterans aged 50–70 were compared to the expected frequencies of the above diagnosis. The expected frequencies were based on the incidence of prostate, urinary bladder and kidney cancer in men aged 50–70 in the Republic of Croatia. For each of the diagnosis, a separate $\chi^2$ test was calculated.

### Ethical approval

The Ethics Commission of the Zadar General Hospital approved the research. All participants in the research had previously been informed verbally and in writing of the aim and purpose of the research and voluntarily signed the consent to participate in the research. Anonymity was ensured to the participants during and after the research. Participants can in no way be related to the results of the research

## Results

During preventive physical examinations held in the period from 1 March 2017 to 31 December 2018, 2101 men, Homeland War veterans, were examined. 1425 (67.8%) participants were in the age group of 50 to 70, while 676 (32.1%) participants were outside the examined age range and were not included in the study.

Out of 52 diagnosed carcinomas, 35 carcinoma sites belonged to urogenital cancers, and 17 newly-discovered cancers fell into other organ systems.

The total proportion of cancer patients was 3.6% (52), while the proportion of patients suffering from urogenital system cancers was 2.4% (35). Of the 35 urogenital system cancers, 24 (1.6%) patients had prostate cancer, 7 (0.4%) patients had urinary bladder cancer and 4 (0.2%) kidney cancer (see Table 1).

**Table 1: The number and percentage of diseased veterans and the general male population aged 50–70 and testing differences**

| | Veterans (N=1425) | General male population (N=559148) | Chi-square test (χ2) (df=1) |
|---|---|---|---|
| | | | Value |
| **Prostate cancer – N (%)** | 24 (1.68) | 1411 (0.25) | 12.1248** |
| **Kidney cancer, except pelvic - N (%)** | 4 (0.28) | 238 (0.04) | 0.8429 |
| **Urinary bladder cancer - N (%)** | 7 (0.49) | 300 (0.05) | 3.9061* |
| **Total - N (%)** | 35 (2.45) | 1949 (0.34) | |

*** P <.01; * P <.05*

The chi-square test (χ2) showed a statistically significant difference in the prevalence of urogenital system cancers between the Homeland War veterans and the general male population of the same age (50–70). The statistical significance of the difference between the prevalence of prostate cancer on the sample of veterans aged 50 to 70 and the prevalence of the same cancer among the general male population in Croatia aged 50–70 is significant χ2 of 12.1248 (df = 1) at a significance level of 1%, which showed more prevalence among Homeland War veterans. The statistical significance of the difference between the prevalence of urinary bladder cancer among veterans aged 50 to 70 and the prevalence of the same type of cancer among the general male population is χ2 of 3.9061 (df = 1) at a significance level of 5%, also more often than the general male population.

The statistical significance of the difference between the occurrence of kidney cancer among the veteran sample of 50 to 70 years and the prevalence of the same cancer among the male population in Croatia is not significant χ2 of 0.8429 (df = 1).

## Discussion

The results of our research confirm a statistically significant prevalence of prostate cancer and urinary bladder cancer among Homeland War veterans compared to the general male population of the same age group (Table 1).

Despite numerous research on various topics related to Homeland War veterans in the Republic of Croatia,[17,27–29] this is the first medical study on the occurrence of malignant diseases to the best of our knowledge. A limited number of such studies have also been reported in world literature. By comparing our study results to the results of similar research, one observes congruence as well as differences. In both previous research[23,24,30–32] and our examined group, prostate cancer appears statistically significantly more often among Croatian veterans than among the general male population of the same age (see Table 1). A survey conducted on Vietnam War veterans investigating the impact of family predisposition and military history on prostate cancer formation highlights family predisposition and exposure to war conditions as risk factors for the development of prostate cancer.[31] Furthermore, the results of a Korean Study in 2013,[24] carried out by Yi who investigated the connection between carcinoma occurrence among Vietnam veterans, showed there was generally no higher incidence of carcinoma among Vietnam War veterans in comparison to the general population. Contrary to expectations, this research suggests a lower incidence of cancer as compared to the general population, which authors attribute to 'the effect of a healthy soldier' indicating a rigorous selection of soldiers. However, in some types of cancer, there is still a higher rate of incidence among Vietnam War veterans in comparison to the general Korean population.[24] A higher incidence of carcinoma among the veteran population is related to prostate, urinary bladder and kidney cancer.[24] which coincides with our results. Unlike the rigorous selection of Vietnam War veterans before going to war, no selection work was carried out on our respondents before they went to war. All men over the age of 18 were eligible to become defenders. The fact that war-related stress affected our veterans, as well as the concern for their family and home, is an aggravating circumstance. Our results are also consistent with the results of the study 'Usual Adult Occupation and Risk of Prostate Cancer in West African Men' conducted in Ghana (West Africa) from 2004 to 2012.[32] The aim of this study was to identify occupations where prostate cancer was most common. In the results, the authors associate military occupations with more frequent appearance of prostate cancer.[32] Due to territorial proximity, we particularly refer to the research conducted in Italy in 2000 which was triggered by the 'Balkans syndrome' media records.

The research included Italian soldiers who were in peacekeeping forces deployed in Kosovo and Bosnia. As a consequence of the use of ammunition containing depleted uranium, they suspected high levels of thyroid cancer and Hodgkin's lymphoma.[33] Although the Italian committee appointed by the Ministry of Defense reported a higher rate of lymphoma and lower rates of other cancers, they did not confirm the correlation with the exposure to depleted uranium.[33] Thus, contrary to expectations, the results of the study did not confirm the increased risk for Hodgkin's lymphoma or thyroid cancer caused by the exposure to depleted uranium among soldiers stationed in Bosnia and Kosovo.[33] Despite the negative results of this research, there was still a suspicion of the link between military service in the Balkans and malignant diseases.[23] The following study conducted in Norway tested the occurrence of cancer and mortality among Norwegian soldiers who were in the UN peacekeeping forces in Kosovo. Also, as in the previous study, the results did not confirm a higher incidence of cancer in comparison to the general population in Norway.[23] However, the same research stated the fact that among the respondents, Norwegian soldiers who had been in Kosovo for more than a year had a greater risk of urinary bladder cancer, which is in accordance with our results. However, this is just an assumption of the author based on three cases and is probably an incidental event of an unknown cause.[23] A frequent occurrence of urinary bladder cancer in our study group (see Table 1), can be explained by the influence of known risk factors such as tobacco smoking, frequent urinary infections, long-term use of antibiotics and exposure to certain chemicals.[34–36] Although we did not have the relevant data in connection to nicotine addiction of our respondents, we assume that the long-term exposure of Croatian war veterans to war-related stress caused a higher rate of addiction and hence a higher incidence of bladder cancer. Our assumption is based on a survey conducted among American soldiers where cigarette smoking was recognised as a negative strategy of soldiers dealing with stress.[36] The above-mentioned research conducted in Italy among soldiers engaged in UN peacekeeping forces in Bosnia and Kosovo did not confirm the frequent occurrence of kidney cancer in the examined group,[33] which is in accordance with our results (Table 1). Nevertheless, the research conducted on Vietnam veterans indicated a higher incidence of kidney cancer among veterans compared to the general population that authors associate with the exposure to harmful chemicals.[24]

Considering the obtained results, we can assume that war and exposure to war events is a strong risk factor for the occurrence of prostate cancer and urinary bladder cancer among male veterans. As active war participants, most often over 1 500 days, Croatian defenders were exposed to a large amount of stress, which many authors in their research consider to be a strong risk factor for many diseases.[2,35] Additional duration of stress is considered to be the main cause of physical and mental exhaustion.2 Therefore, Flores et al. connect stress directly with the development of prostate cancer, assuming that it affects the neuroendocrine mechanisms changing genetic material and thus creating the basis for the emergence of malignant neoplasm.[3]

The lack of our research is evident in terms of comparison of unequal groups of respondents, i.e. comparison of a group of war veterans to the general male population. However, a significant reduction of such deficiency can be observed in the fact that the prevalence of prostate, urinary bladder and kidney cancer among the general male population of 50 to 70 years of age in the Republic of Croatia has been relatively stable in recent years. Furthermore, compared to previously published results of Swedish[25] and Danish studies,[37] our research does not represent systematic monitoring of the occurrence of carcinoma among veterans, but it is rather a one-time measurement.

The advantage of our research is that it involves a large number of Croatian veterans aged 50 to 70 and mostly uses objective parameters of clinical findings derived from the preventive program rather than questionnaires that respondents fill out based on their own knowledge of their health status. Furthermore, there is a great response of Croatian veterans to physical examinations, which confirms their awareness of the risk they were exposed to. High responsiveness can also be linked with personal care and interest for their own health as well as possible fear of the test results. Additionally, prominent unity and trust among Croatian veterans created in war circumstances, continues in their postwar grouping, which has an important effect on the response to physical examinations.

Despite the former research[1,29] on the correlation of war-related stress and the psychological difficulties of the veterans, our results suggest a further need to implement the Physical Examination Plan for Veterans and the need for systematic and detailed monitoring and testing of the connection between organic diseases and exposure to stressful war events.

According to our plans, future research will include the incidence of other types of cancer among veterans and the connection between cancer incidence and the previous inclusion of veterans in supportive psychological programs.

## Conclusion

The number of newly-discovered prostate and bladder cancers in the population of Croatian veterans aged 50 to 70 is statistically significantly more common than the number of the same cancers detected among the general male population of the same age group. The exposure of Homeland War veterans to war events and long-term war-related stress is a strong risk factor for the development of prostate and bladder cancer.

*Corresponding Author: Gusar, Ivana*
*Authors: Sorić, Tomislav[1,2] Gusar, Ivana;[1,3] Zekanović, Anita[4] Vidić, Ivan;[4] Dželalija, Boris;[1,4]*
*Author Affiliations:*
*1 University of Zadar Department of Health Studies*
*2 Zadar General Hospital*
*3 Josip Juraj Strossmayer University of Osijek Faculty of Medicine*
*4 Zadar General Hospital*

## References

1. Munjiza J, Britvic D, Radman M, Crawford MJ. Severe war-related trauma and personality pathology : a case-control study. BMC Psychiatry. 2017;1 (100):1–8.
2. Lazarus R, Folkman S. Stress, assessment and coping. Slap. Zagreb: 2004.
3. Flores IE, Sierra-Fonseca JA, Davalos O, Saenz LA, Castellanos MM, Zavala JK, et al. Stress alters the expression of cancer-related genes in the prostate. BMC Cancer. 2017;17(1).
4. Government of Croatia, Ministry of Health. An investigation of the abolition and mortality of Croatian defenders [Internet]. [cited 2018 December 6]. Available from: https://branitelji.gov.hr/istrazivanje-pobola-i-smrtnosti-hrvatskih-branitelja/805.
5. Croatian Encyclopedia. Homeland war [Internet]. The Lexicographic Institute Miroslav Krleža. [cited 2018 September 28]. Available from: http://www.enciklopedija.hr/natuknica.aspx?ID=1588.
6. Government of Croatia, Ministry of Defence. National Program of Psychosocial and Health Aid for Participants and Victims of Homeland War, World War II, and returnees from peacekeeping missions [Internet]. [cited 2018 December 6]. Available from: https://branitelji.gov.hr/UserDocsImages/dokumenti.
7. Mavar M, Kraljić J, Krajnović F, Pletikosa M, Balorda L, Petrić A. The Health picture of the population of Zadar County and the Strategic Plan for Health. Zadar: County of Zadar: 2008.
8. Murthy RS, Lakshminarayana R. Mental health consequences of war: a brief review of research findings. World Psychiatry [Internet]. [cited 2019 November 10]. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16757987%0A http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC1472271
9. Toole BO, Pierse K, Friedrich B, Outram S, Dadds M, Catts S. Combat Posttraumatic Stress Disorder and Health of Australian Vietnam Veteran Conscripts and Volunteers in the Three Decades After Return. Journal of military and veterans' health. 2019;1:42–57.
10. Schwarzer R, Schulz U. The role of stressful life events. Compr Handb Psychol. 2002;9:27–49. [Internet]. [cited 2019 September 12]. Available from: http://userpage.fu- berlin.de/~health/materials/lifeevents.pdf
11. Sheldon Cohen P, Denise Janicki-Deverts P, Gregory E. Miller P. Psychological Stress and Disease. J Am Med Assoc. 2007;298(14):1685–7. doi:10.1001/jama.298.14.1685
12. Maria E, Reiche V, Odebrecht S, Nunes V, Morimoto HK. Review Stress, depression, the immune system, and cancer. 2004;5(October):617–25. doi: 10.1016/S1470-2045(04)01597-9
13. Havelka M, Meštrović Havelka A. Biopsihosocian health determinants. Health Polytechnic. Zagreb: 2013.
14. Denaro N, Tomasello L, Russi EG. Cancer and stress: what's matter? From epidemiology: the psychologist and oncologist point of view. J Cancer Ther Res [Internet]. [cited 2019 November 11]. Available from: http://www.hoajonline.com/jctr/2049-7962/3/6

15. Moreno-Smith M, Lutgendorf K S, Sood K A. Impact of stress on cancer metastasis. Glob J Multidiscip Stud [Internet]. [cited 2019 November 11]. Available from: http://gjms.co.in/index.php/gjms/article/view/46/72
16. Thaker PH, Lutgendorf SK, Sood AK. The neuroendocrine impact of chronic stress on cancer. Cell Cycle. 2007;6(4):430–3.
17. Šućur Z, Babić Z, Jelena O. Demographic and socioeconomic features of Croatian defenders [Internet]. Zagreb; 2017. [cited 2018 September 15]. Available from: https://www.dzs.hr/Hrv/publication/studije/Demografska%20i%20socioekonomska%20obiljezja%20h rvatskih%20branitelja_Web.pdf.
18. Reljić A, Čukelj P, Tomašković I, Ružić B, Šekerija M. Epidemiology of prostate cancer in croatia – situation and perspectives. ActaClin Croat. 2018;57:27–34.
19. Markić D, Oguić R, Sotošek S, Krpina K, Ahel J, Materljan M, et al. Incidence, clinical evaluation and surgical treatment of patients with renal cell cancer: 40-years of experience in the University Hospital Rijeka. 2017;53(3):337–43.
20. Vrdoljak E, Šamija M, Kusuć Z, Petković M, Gugić D, Krajina Z. Clinical oncology. Zagreb: Medicinska naklada; 2013.
21. Croatian Institute for Public Health. Cancer incidence in Croatia [Internet]. Zagreb: 2015. [cited 2018 September 22]. Available from: https://www.hzjz.hr/wp-content/uploads/2018/03/Bilten_2015_rak_final.pdf.
22. Reljić A, Čukelj P, Tomašković I, Ružić B, Šekerija M. Epidemiology of Prostate Cancer in Croatia - Situation and Perspectives. ActaClin Croat. 2018;57:27–34.
23. Strand AL, Martinsen IJ, Borud KE. Cancer risk and all-cause mortality among Norwegian military United Nations peacekeepers deployed to Kosovo between 1999 and 2011. Cancer Epidemiol [Internet]. 2014;5–9. [cited 2018 September 28]. Available from: http://www.eu- focus.europeanurology.com/article/S2405-4596(16)30093-1/fulltext doi: http://dx.doi.org/10.1016/j.canep.2014.04.003
24. Yi S. Cancer Incidence in Korean Vietnam Veterans During 1992-2003: The Korean Veterans Health Study. J Prev Med Public Heal. 2013;309–18. Medline: 24349652 doi:10.3961/jpmph.2013.46.6.309
25. Gustavsson P, Malback A, Lundin A, Lagercrantz B, Gyllestad P, Fornell L. Incidence of cancer among Swedish military and civil personnel involved in UN missions in the Balkans 1989–99. OccupEnv Med. 2004;61:171–3. Medline: 14739385 doi:10.1136/oem.2002.005538
26. Croatian Bureau of Statistics. Estimates of the Republic of Croatia's Population in 2015 2016 [Internet]. [cited 2018 September 22]. Available from: https://www.dzs.hr/Hrv_Eng/publicati on/2016/07-01-04_01_2016.htm.
27. Šćurković S, Mikloušić I, Knežević M. Psychosocial adjustment of Croatian homeland war veterans: individual and social perspective. 2017. Zagreb: Institute of Social Sciences Ivo Pilar; 2017.
28. Benčić A. Personal Memories of Participants of the Croatian War of Independence. Journal for general social issues. 2017;26(3):341–62. doi: https://doi.org/10.5559/di.26.3.02
29. Antičević V, Kardum G, Britvić D. War Veterans' Quality of Life: the Impact of Lifetime Traumatic Experiences, Psychological and Physical Health-Related Characteristics. J Gen Soc issues [Internet]. 2011;20(4 (114)):1101–18. Available from: http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=112691
30. Noon AP, Martinsen IJ, Catto JWF, Pukkala E. Occupation and Bladder Cancer Phenotype : Identification of Workplace Patterns That Increase the Risk of Advanced Disease Beyond Overall Incidence. EurUrol Focus [Internet]. 2016;44(0):1–6. Available from: http://dx.doi.org/10.1016/j.euf.2016.06.014
31. Leavy J, Ambrosini G, Fritschi L. Vietnam military service history and prostate cancer. BMC Public Health. 2006;6:1–6.
32. Adler C, Friesen MC, Yeboah ED, Tettey Y, Biritwum RB, Adjei AA, et al. Usual adult occupation and risk of prostate cancer in West African men: the Ghana Prostate Study. OccupEnv Med. 2018;1–7.
33. Peragallo SM, Lista F, Sarnicola G, Marmo F, Vecchione A. Cancer surveillance in Italian army peacekeeping troops deployed in Bosnia and Kosovo, 1996–2007: Preliminary results. Cancer Epidemiol. 2010;34:47–54.

34. George M, Cumberbatch K, Jubber I, Black PC, Esperto F. Epidemiology of Bladder Cancer: A Systematic Review and Contemporary Update of Risk Factors in 2018. EurUrol [Internet]. 2018;1–12. Available from: https://doi.org/10.1016/j.eururo.2018.09.001
35. Homish GG, Hoopsick RA, Heavey SC, Homish DL, Cornelius JR. Drug Use and Hazardous Drinking Are Associated With PTSD Symptoms and Symptom Clusters in US Army Reserve / National Guard Soldiers. Am J Addict. 2019;28:22–8.
36. Lopez AA, Toblin RL, Riviere LA, Lee JD, Adler AB. Correlates of current and heavy smoking among U.S. soldiers returning from combat. Exp Clin Psychopharmacol. 2018;23(3):215–22.
37. Storm HH, Ole H, Mette A, Kejs T, Engholm G. Depleted uranium and cancer in Danish Balkan veterans deployed 1992–2001. Eur J Cancer [Internet]. 2006;42(14):2355–8. Available from: http://dx.doi.org/10.1016/j.ejca.2006.01.064

# Infection Prevention and Control Practices in the Deployed Military Field Hospital: AN integrative review

*J Skipp, P Zimmerman, T Van de Mortel*

Abstract

**Background:** Advances in personal protective equipment, tactical combat casualty care training and improved technologies have led to the increased survival of those injured during combat. However, infection remains a significant complication in combat-related injuries, from initial wound contamination to infections acquired in various treatment facilities.

**Purpose:** To determine contemporary infection prevention and control (IPC) practices used to reduce healthcare-associated infections (HAIs) in the Australian Defence Force (ADF) deployed Medical Treatment Facilities (MTFs).

**Method:** An integrated literature review was conducted into the IPC practices of ADF and internationally deployed MTFs.

**Results:** Thirteen articles were reviewed and five main themes were obtained. For effective IPC, deployed MTFs require IPC-specific standard operating procedures, strict adherence to basic IPC practices, a robust antimicrobial stewardship program and deployed personnel with the relevant expertise and knowledge in IPC.

**Conclusion:** Infection prevention and control in deployed MTFs comes with its own unique set of challenges. For deployed MTFs, establishing effective IPC practices and procedures will reduce the risk of HAIs and minimise the risk of further harm occurring to injured personnel.

**Keywords:** infection prevention, infection control, military, military hospital, field hospital

**Conflict of interest:** The author(s) declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

## Introduction

Healthcare-associated infections (HAIs) are difficult to prevent even in the most optimal healthcare environments.[1] Mitchell and Shaban report approximately 165 000 HAIs occur per year in Australia.[2] By comparison, the delivery of optimal healthcare in the deployed Medical Treatment Facilities (MTF) of the Australian Defence Force (ADF) faces many challenges.[3] These include the complex requirements of the supported force, austere or hostile environments, lack of health personnel and limited logistical support.[3] Advances in personal protective equipment (PPE), tactical combat casualty care training and improved technologies have led to the increased survival of those injured during combat.[4,5] However, infection remains a significant complication in combat-related injuries, from initial wound contamination to infections acquired in various treatment facilities.[6,7]

In the field, wounds are initially contaminated with environmental exogenous flora including *Clostridium sp., Bacillus cereus, B. subtilis, Pseudomonas aeruginosa* and *P. stutzeri* as well as dust, clothing debris and other foreign materials that are driven into the wounds by explosions.[6,8] Fungal species such as *Mucor sp., Aspergillus sp.* and *Fusarium sp.,* commonly found in the soil in agricultural settings, have also been found to contaminate the wounds of soldiers from the United Kingdom (UK) and United States (US).[9] Within deployed MTFs, HAIs are caused by multidrug-resistant organisms (MDROs) such as *P. aeruginosa, Acinetobacter baumannii-calcaoceticus* complex, *Enterobacteriales, Staphylococcus aureus,* enterococci or yeast.[4,6,7] These infections are nosocomial and likely to have been spread from multiple sources within the area of operations, more specifically in healthcare settings.

If the MTF has been deployed in order to provide support humanitarian operations, initially wound infections will be seen due to trauma usually within 0–4 days. During the post impact phase (0–4 weeks) the MTF is likely to see an increase in airborne, food-borne and waterborne infections.[10] It is also likely the MTF will see infections caused by *Staphylococcus aureus*, group A streptococci, norovirus and adenovirus. Droplet spread infections include influenza virus, *Mycoplasma pneumoniae* pneumonia, whooping cough, rubella and mumps. The facility is also likely be required to treat patients with airborne diseases such as measles and tuberculosis. Decreasing the risk of transmission of the various diseases would prove challenging in the deployed environment.[11]

Within a military theatre of operations, care of the casualty commences at the point of injury (POI) with self aid, buddy aid, combat first aiders and medical technicians. Casualties are then transported to the next level of care, via armoured ambulances or medivac helicopter, depending on several factors: the combat situation, weather, terrain or transport assets available. While a Role 1 MTF may be available to provide non-specialist led advanced first aid and resuscitation, casualties are often transported from POI directly to either a Role 2 or a Role 3 MTF for specialist led treatment (Figure 1). Casualties are then evacuated to a civilian health facility outside of the combat zone[7] as depicted in the Combat Health Operating System in Figure 1.[12] Ensuring that HAIs are prevented while care is being provided along the complex evacuation chain is very challenging.

Various factors including the physical structure of the facilities (which can range from a series of interlocking tents to pre-existing buildings), the regular and constant turnover of healthcare workers (HCW), unfamiliarity with another nation's MTF IPC procedures (for example, an ADF HCW deployed to work with a coalition partner's MTF), climate (ranging from extreme cold to extreme humidity) and the presence of dust and sand (which greatly impacts on the successful cleaning of the environment) significantly challenge the prevention and management of HAIs.[7] Other challenges include the provision of care to local nationals and the supply chain.[3,7] There is no standardised clinical governance (CG) framework for the deployed setting; various ADF MTFs deploy with their own set of standards and guidelines. In contrast, the provision of healthcare to the ADF within Australian bases is facilitated by an organisation called Joint Health Command (JHC) utilising an integrated workforce that include defence members, civilians, contractors and other health

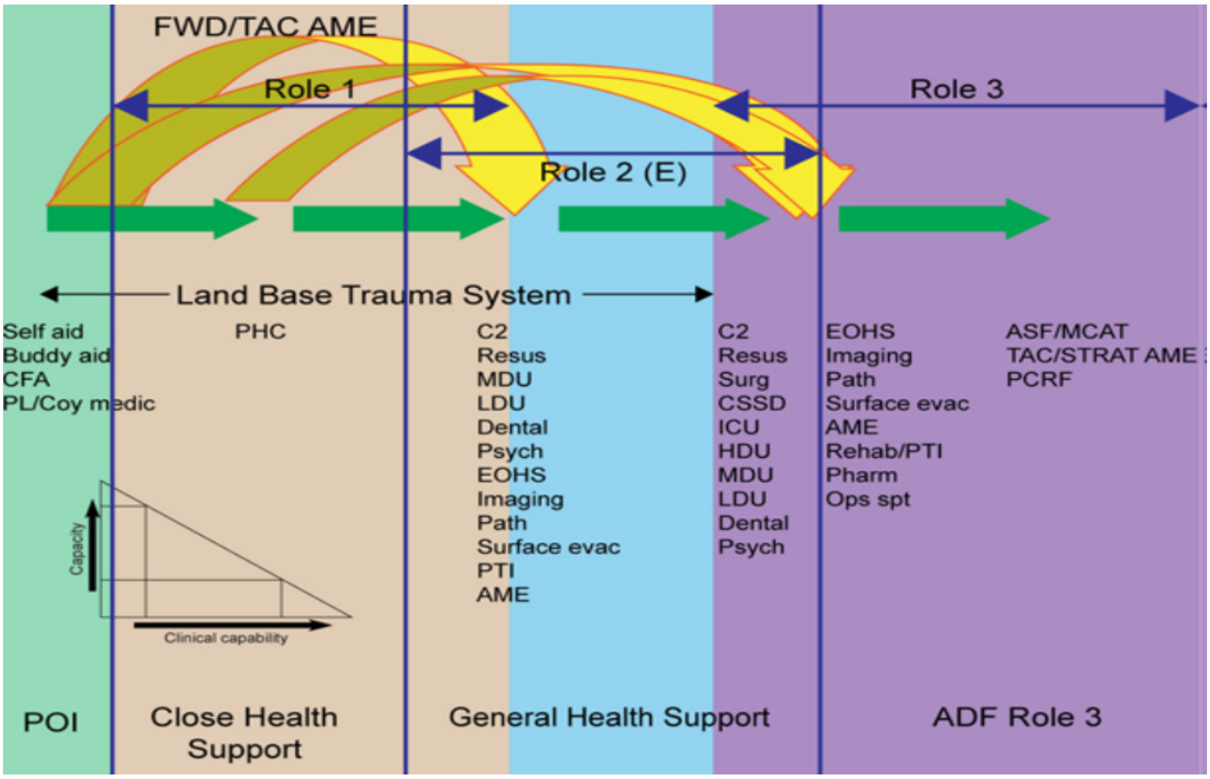


*Figure 1. Combat Health Operating System (Commonwealth of Australia, 2015)[10]*

professionals.[13,14] The health standards that JHC and the ADF apply to garrison healthcare have been produced in conjunction with The Royal Australian College of General Practitioners (RACGP) *Standards for Garrison Health Facilities in the Australian Defence Force*. These standards provide a robust template for the delivery of safe and effective healthcare to the ADF, including IPC practices.

The Australian Army's deployable surgical capability (NATO Role 2E or R2E) is provided by the 2nd General Health Battalion (2GHB). The unit has developed a CG framework to improve the services it provides and recognises the benefits of aligning with, and meeting, the standards of care equal to that provided within public and private civilian hospitals. To achieve this, 2GHB has implemented a continuous quality improvement (CQI) project that benchmarks against the national standards provided by the Australian Commission for Safety and Quality in Health Care (ACSQHC).[3,15,16]

This integrated review aims to investigate the contemporary international literature on the current practice strategies being utilised to improve IPC within the challenging combat environment. This will be used to inform 2GHB's IPC practices as well as informing the IPC practices of the Royal Australian Airforce (RAAF) and Royal Australian Navy (RAN) deployable MTFs, and care provided by the Army's 1st Close Health Battalion (1CHB), which provides close health support to the ADF. Defence forces from other countries may also use the information to improve their IPC practices.

### Literature review – Search methods

An integrative review method[17] was used to investigate current IPC practices. This methodology uses a systematic and rigorous method of reviewing data from various sources (experimental and non-experimental) improving the quality of data analysis and has the potential to allow for diverse primary research methods to play a greater part in evidence-based practice initiatives.[14,15]

A literature search of five bibliographic databases was conducted, which included Cumulative Index to Nursing and Allied Health Literature (CINAHL) Plus with full text, Medline, EMBASE, PubMed and ScienceDirect for articles published from January 2009 to January 2019. The search terms used in all databases were 'infection control' OR 'infection prevention' AND 'military', OR 'military hospital' OR 'field hospital'. The search terms were entered into the individual databases using the advanced settings and were used to search by title, abstract and keyword.

To broaden the search, the reference lists of the selected articles were examined to identify other potentially relevant sources. Limiters for the search included English only full-text articles from 2009 to 2019, peer-reviewed to ensure currency of information. Exclusion criteria for the initial search included:

- editorials and correspondence
- items that were not journal articles, reviews, publications, government documents or observational studies
- items written in languages other than English
- published prior to 2009
- items not involving infection prevention, infection control, deployed military treatment facilities and field hospitals.
- The inclusion criteria were then refined to focus on the discussion of IPC practices utilised in deployed MTFs or field hospitals.

### Quality assessment

The quality of the articles was assessed utilising the Mixed Methods Appraisal Tool (MMAT).[19] Using this tool, the quality of articles was scored independently by two authors (JS and PZ) and assessed against the appropriate methodological criteria.

## Results

The search yielded a total of 1649 original articles. A total of 627 were discarded as they did not meet the inclusion criteria leaving 1022 articles. The study titles were reviewed leaving a total of 65 articles. The abstracts of these articles were screened leaving a total of 16 articles. An in-depth review of the full text and methodology was conducted, which left a total of 13 that met the inclusion criteria and identified current practice strategies being utilised to improve IPC within the challenging combat environment. Figure 2 demonstrates the search strategy. Based on the MMAT assessment and methodological criteria, article quality ranged from 50–100%.

A summary of the included articles is provided in Table 1. Of the 13 articles reviewed, 11 articles had four main common themes that were discussed within each article. These themes are: 1) requirement for IPC expertise and education within deployed MTFs; 2) maintaining an emphasis on basic IPC measures (hand hygiene, environmental cleaning, and cohorting of patients); 3) the use of standard operating procedures (SOPs) and guidelines; and

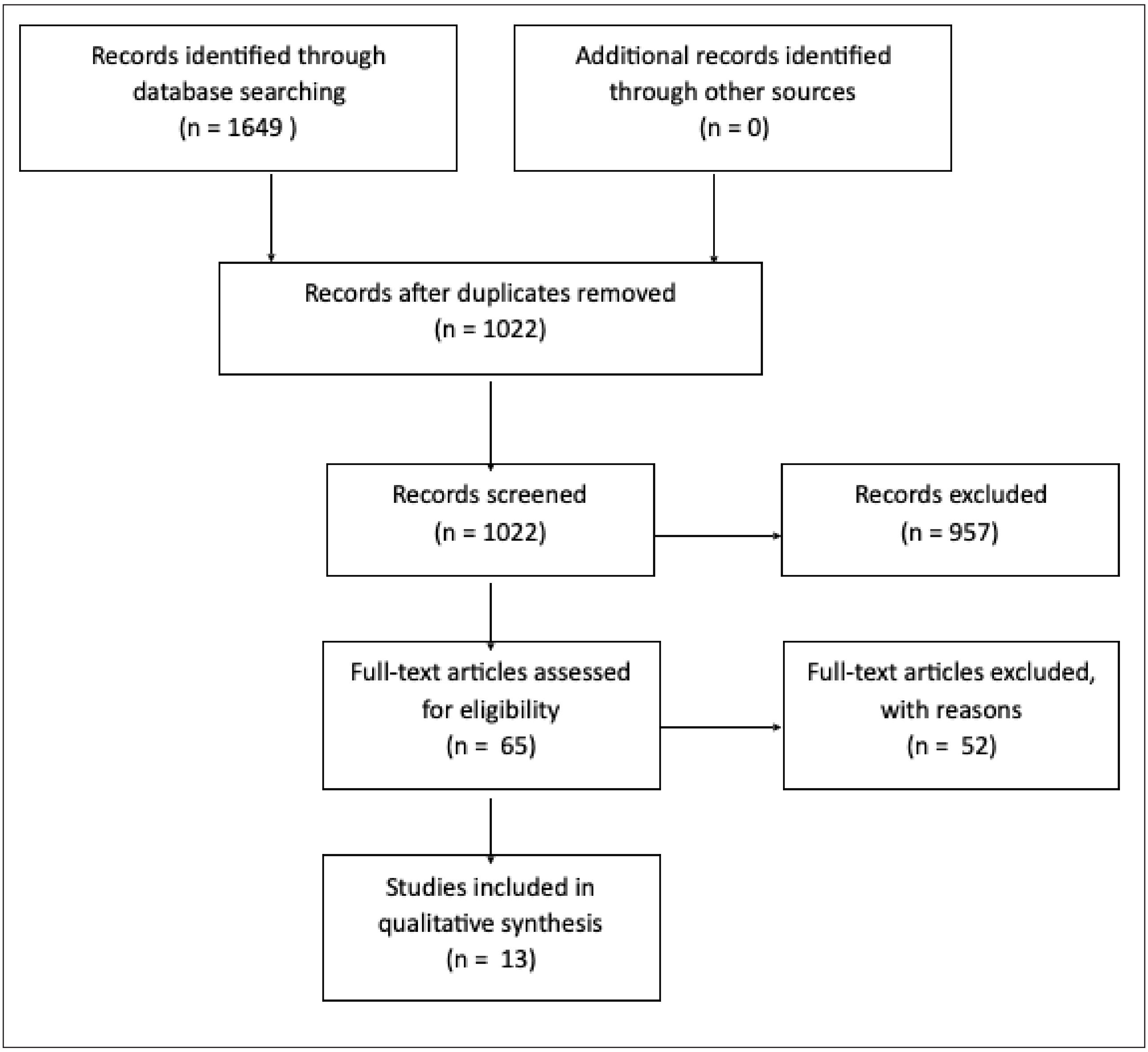


*Figure 2. PRISMA diagram of search results*

4) antimicrobial stewardship. These themes were present across various settings including Iraq, Afghanistan, Nepal, Liberia and Sierra Leone. One article describes the introduction of a five-day predeployment IPC course for personnel deploying as an Infection Control Officer (ICO) within the MTFs. Another presents a case study of the deployment of the 1st Health Support Battalion (1HSB) to Exercise Talisman Sabre in 2009 during an H1N1 outbreak describing the challenges faced, highlighting the need for careful predeployment planning, ongoing education of HCW, surveillance and maintenance of basic IPC procedures.

**Table 1. Summary of articles included in review.**

| Author (Year) Location | Aim | Methods | Study Findings | Limitations | MMAT scores |
|---|---|---|---|---|---|
| Crouch et al. (2010) USA | To describe the development of a 5-day deployment-unique IC course. Effectiveness of the course was assessed through a pre- and post-test and through the use of follow-up survey of deployed personnel who took the course. | Descriptive article.<br>Pre- and post-test.<br>Follow-up survey. | Assessment of knowledge<br>18 students received the pre- and post-tests. Average pre-test score was 65% (min-max, 38%–88%) and post-test score 86% (min-max, 71%-10%) with average score increase of 21% (min-max, 8%–33%) (paired sample T-test, $p<0.01$; CI, 15–27). Areas missed in pre-test: disinfection and sterilisation, isolation practice, post-exposure prophylaxis and multidrug-resistant organisms. Clear improvement on post-test scores.<br>Attendees who deployed in the role of ICOs found the course improved their knowledge of IC procedures and ensured that they were able to perform their assigned role effectively. | Response bias may be present with a 43% response rate to the survey<br>No patient outcome data to assess effectiveness of strategy. | 75%<br>Unclear if appropriate consideration given to how findings relate to researchers' influence. |
| Fletcher et al. 2013 UK | Evaluation of antimicrobial prescribing practices by military clinicians in patients admitted to the UK/US Role 3 medical treatment facility in Camp Bastion, Afghanistan, against the published UK guidelines. | A retrospective case note review during two periods (October 2011 and October 2012).<br>475 case notes reviewed.<br>250 received antimicrobials. | Adherence levels to correct antimicrobial use superior in the deployed environment than civilian hospitals due to patients admitted for a single condition, treatment provided by senior clinicians, daily pharmacist reviews.<br>Introduction of multidisciplinary antimicrobial ward rounds attended by hospital pharmacists, trauma and orthopaedic consultants, general surgical and medical consultants, to monitor guideline compliance, limits duration and overuse of broad-spectrum antibiotics, and reinforces the importance of infection prevention to all disciplines.<br>Ward rounds should be supported with real-time monitoring of operational data on prescribing and consumption. | Study only conducted in the Role 3 Camp Bastion.<br>Study sample size relatively small. | 100% |
| Hospenthal et al. 2011 USA | To review the history and challenges of HAIs in deployed MTFs as they pertain to caring for combat-injured personnel. Also, review the history and current practice strategies to decrease or prevent infections. | Descriptive Study. | IPC in the deployed setting has unique challenges. Specific areas of improvement have been identified:<br>• IPC expertise<br>• Emphasis on basic IPC measures<br>• Use of standardised procedures and guidelines<br>• Antimicrobial control. | Reviewed only US MTFs | 50%<br>Unclear if appropriate consideration given to how findings relate to researchers influence. |

| Author (Year) Location | Aim | Methods | Study Findings | Limitations | MMAT scores |
|---|---|---|---|---|---|
| Hospenthal et al. (2010) USA | A 2008 review of deployed MTFs to identify the factors impeding the performance of IPC practices. | A review of the IPC practices and challenges was conducted within the combat theatre as well as the evacuation route (Feb to March 2008). | Increased awareness of basic IPC practices, including HH, use of transmission-based precautions, cohorting of patients, imparted to leaders and deploying personnel. Enhancement of IPC expertise, IPC SOPs, IPC teleconsultation service and dedicated internet resources. Standardised admission colonisation screening of patients. A repeat review found improvement in IPC practices. | Review only conducted in US MTFs | 75% Unclear if appropriate consideration given to how findings relate to researchers' influence. |
| Johnson et al. (2009) USA | To describe the rates of device utilisation (DU) and device-associated infections at the Air Force Theatre Hospital (AFTH), a CSH in Iraq and to compare them to published rates of US trauma ICUs to identify improvement measures in these facilities. | Retrospective review of IC records in the AFTH from Nov 2006 to Dec 2007. Monthly DU and infection rates (per 1000 device days) were compared and analysed for trend and compared with pooled means for US trauma ICU's. | Central line utilisation rates were constant with CLABSI rates of 0 to 7.7 per 1000 device days. The IPC program reduced VAP rates to a baseline 9.7 –11.6. The IC program included reinforcement of HH, contact precautions for infected patients with MDROs and patient and staff cohorting. | Observer bias present with the number of pers involved in the collection of the data. There may have been a wide disparity in each observer's objectives and perceptions of infection. US only. Data only collected from on AFTH in Iraq. | 75% Unclear if appropriate consideration given to how findings relate to researchers' influence. |
| Lei Liu et al. (2017) China | Describe the main IC initiatives employed during the Ebola epidemic in Liberia. | Case Study. | Report describes the IPC initiatives under three headings. Optimisation of the ETU design Comprehensive IC initiatives, staff training and communication. | No limitations observed. | 75% Unclear if appropriate consideration given to how findings relate to researchers' influence. |
| Yinying et al. (2016) China | Provide an overview of the rescue mission of the Chinese Military Medical Teams in Sierra Leone. Describes the practical experiences on predeployment preparedness, EVD holding and treatment centres building and EVD case management. | Case study. | 4-week predeployment course covering language, local culture, EVD virological knowledge, PPE usage, EVD clinical care, facility sterilisation and public sanitation. Strict adherence and monitoring of the use of PPE, surveillance 24hr via video cameras. Early confirmation of EVD utilising PCR testing. Timely patient quarantine, early diagnosis and effective care of EVD SOPs for PPE use, EVD management, EVD nursing and hospital infection control | No limitations observed. | 75% Unclear if appropriate consideration given to how findings relate to researchers' influence. |

| Author (Year) Location | Aim | Methods | Study Findings | Limitations | MMAT scores |
|---|---|---|---|---|---|
| Yun et al. (2016) USA | To provide observations from recent conflicts split into five categories of general knowledge, which can be applied to current and future conflicts. | Descriptive study article. | The predominant source of MDR GNR colonisation and HAIs in US combat casualties is nosocomial. There is a responsibility on the chain of tactical combat casualty care to minimise the risk of HAIs through careful attention to IC procedures.<br>Microbiology expertise is required in the deployed environment, so changes in microbiology can be met with real-time interventions such as changes in prophylactic and empiric therapy. A flexible approach to prevention is necessary.<br>Expertise in IPC must be developed and deployed.<br>Systems for research and surveillance must be in place<br>Basic IPC interventions are effective in combat space. Development of IPC policies and procedures including the predeployment training of ICOs, development and application of theatre-wide IPC and bloodborne pathogen exposures policies, deployed microbiology capabilities, contracts, supplies and equipment relating to IPC and hospital cleaning. | US facilities only. | 75%<br>Unclear if appropriate consideration given to how findings relate to researchers' influence. |
| Merens et al. (2014) France | Determines the principles of antimicrobial prophylaxis for war wounds recommended by the French Armed Forces. | Descriptive article | Maintenance of standard precautions<br>Continuous training on hygiene standard precaution, contact precautions, antibiotic stewardship. | Limited to the French MTFs. | 50% |
| Hospenthal and Crouch (2009) USA | A review of the IC practices and challenges within the combat theatre and evacuation routes. | Role 3 facilities (hospitals capable of holding patients > 72 hours) in Iraq and Afghanistan and the evacuation system from Iraq to continental US were reviewed by expert IPC infectious-disease team. | IPC programs were established but staffed with personnel with limited IC experience.<br>HH found to be inadequate<br>Isolation and cohorting of patients with MDROs varied between facilities.<br>Variability of SOPs between facilities and inadequate in some facilities<br>Application of US national and theatre-specific guidelines and antimicrobial control measures also varied among facilities. | US only<br>Total number of facilities reviewed not documented. | 75%<br>Unclear methodology of data collection. No tool used to evaluate the IC program. |
| Currie et al. (2010) Australia | Provide a case review of the 1 HSB's response to the H1N1 outbreak during EX Talisman Sabre 09. | Case study | Early identification of patients with suspected Influenza-like illness.<br>Difficulties in establishing H1N1 positive patients.<br>Isolating patients was challenging.<br>Number of consumables required was underestimated and difficult to procure.<br>Education to HCW and patient required to reinforce IC principles.<br>Units SOPs required revision.<br>Patients were isolated away from the main hospital. | 1 HSB experience only.<br>Case study. | 75%<br>Unclear if appropriate consideration to how findings relate to researchers influence. |

| Author (Year) Location | Aim | Methods | Study Findings | Limitations | MMAT scores |
|---|---|---|---|---|---|
| Zheng et al. (2016) China | Provide a review of the orthopaedic treatment provided Rescue Centre of Trauma by the Peoples Republic of China post the 2015 Earthquake in Nepal. | Case Study. | IC was the key determinant for the success of the orthopaedic surgeries performed. These included strict environmental disinfection, extending sterilising time of fixation devices and supplies, doubling the number and time of washing and disinfection and the rational use of antibiotics. | Limited to the Chinese military experience. | 50%<br>Can't tell if the process of analysing qualitative data is relevant to address the objective<br>Unclear if appropriate consideration given to how findings relate to researchers' influence. |
| Vane et al. (2010) USA | Provide an overview of the IC practices required in a disaster situation | Information article. | Establishing surveillance programs.<br>Developing standard case management protocol agreement on polices of prevention.<br>Having reserve supplies of essential medical supplies.<br>Identifying treatment sites, triage systems, training needs, expert assistance for epidemic investigation along with access to microbiology to confirm index cases of epidemic disease.<br>Quick implementation of community education and evaluation programs.<br>Establishing and monitoring IC practices of HCWs.<br>Requirement for dedicated ICO to implement and monitor the IPC program. | Implementing basic IC practices in disaster situations. | 100% |

Abbreviations
AFTH – Airforce Theatre Hospital
CLABSI – Central Line-associated Blood Stream Infection
ETU – Ebola Treatment Unit
EVD – Ebola Virus disease
HAIs – Health-associated Infections
HH – Hand Hygiene
IC – Infection Control
ICO – Infection Control Officer
ICU – Intensive Care Unit
ILI – Influenza-Like Illness
IPC – Infection Prevention and Control
MDROs – Multidrug-Resistant Organisms
MDR GNR – Multidrug-resistant gram-negative rods
MMAT – Mixed method appraisal tool
PCR – Polymerase Chain Reaction
PPE – Personal Protective equipment
SOP – Standard Operating Procedure
UK – United Kingdom
US – United States
VAP – Ventilator-associated pneumonia

### Infection prevention and control training and expertise

In a review by Crouch, Murray and Hospenthal of IPC practices within the theatre of operations of Iraq and Afghanistan, the authors identified standard IPC practices were not being implemented consistently across the various MTF's within the theatre of operations potentially increasing the risk of HAI's.[5] They described the need for, and development of, a five-day predeployment course focusing on IPC in the deployed setting. This ensured that the ICO assigned to the deployed MTF had the relevant skills and knowledge to oversee and manage the infection control (IC) program within their facility ensuring compliance to IPC practices.[5] All course attendees deployed to a Role 3 MTF. The course proved to be effective allowing the participants to perform their roles as ICO within the facilities. The requirement for IPC expertise and ongoing education is described in a further eight articles.[1,4,7,17-22]

### Basic IPC measures

Of the 13 articles reviewed, nine described the importance of maintaining basic IPC measures.[1,4,7,17-19,21-23] These articles described ensuring that hand hygiene (HH) is performed and monitored for compliance. Alcohol-based hand rubs (ABHR) should be available for use within combat zones and there should be strict adherence to the correct use of PPE to reduce infection risk to HCWs as well as patients.[21,22] Modifications to isolation precautions required in the deployed environment are shown in Table 2.[7] Frequent environmental cleaning is also required as part of IPC.[23]

### Standard operating procedures

The revision and development of SOPs relating to IPC are discussed in three articles. Currie describes the ongoing continual revision and development of the SOPs utilised by 1HSB during the H1N1 outbreak in 2009.[27] Hospenthal and Crouch in their review of the IPC practices and challenges within the combat theatre and evacuation routes found that there was distinct variability of the SOPs within the various MTFs and the SOPs were often found to be inadequate.[4] They emphasised the need to develop theatre-wide IPC SOPs, which could be adapted by the local ICO if required for the individual MTFs.

### Antimicrobial stewardship

Antimicrobial stewardship (AMS) is a key strategy in limiting antimicrobial resistance and decreasing preventable HAIs.[28] This is discussed in depth in five of the 13 articles reviewed.[4,7,17,18,26] An evaluation of antimicrobial prescribing habits in the UK/US Role 3 MTF at Camp Bastion Afghanistan was conducted

**Table 2. Isolation precautions to prevent transmission of infections in deployed hospitals Adapted from: Hospenthal and Crouch**

| Isolation category | Patient placement | Healthcare worker PPE |
|---|---|---|
| **Contact precautions** | Ideal: Single room.<br>Option: Bed separated from others by 2 metres. | Ideal: Disposable gowns and gloves for all possible interactions with the patient or items within the patient zone. PPE and HH between patients.<br>Option: Gloves with removal and HH after each patient interaction. |
| **Droplet precautions** | Ideal: Single room.<br>Option: Patients with same symptoms cohorted. Separation of 2 metres with curtains between patients. If no curtains separation of 3 metres between patients. | Ideal: Mask when entering the room.<br>Option: Mask within 3 metres of the patient.<br>Patients to wear masks when transported. |
| **Airborne precautions** | Ideal: Single room with negative pressure ventilation. Air discharged to the outdoors. Doors to remain shut.<br>Option 1: Single room with a fan exhausting then air outward. Door to remain shut.<br>Option 2: If no single room available, the patient is to be admitted as far away from other patients as possible with a physical barrier around the patient. Do not admit the patient near air intakes.<br>Option 3: Patients admitted to a single quarter separate from the main facility. | Ideal: N95 mask when in the patient room. HCW should be fit tested using the N95 masks supplied by the facility.<br>Option: N95 mask as above without fit test.<br>Patient to wear surgical mask during transport. |

*Adapted from Hospenthal, Green and Crouch* [7] in October 2011and 2012.[29] It found adherence to the prescribing guidelines was superior to that found in civilian hospitals. This is most likely due to the patients being treated by senior medical consultants and daily checks of prescribing habits conducted by the pharmacist. The strict monitoring of antimicrobial use is advocated in the other four articles.[4,7,20,21]

## Discussion

The maintenance of an effective and efficient IPC program in modern civilian healthcare has many challenges.[1] In the deployed setting, these challenges are the same along with unique challenges that come with working within a theatre of combat.[7] High personnel turnover, care of local nationals who are a potential source of MDROs[4], the physical structure of the MTF, extremes in weather and the potential shortage of essential supplies for effective IPC pose challenges to optimising IPC.[7]

Previously within US MTFs, and currently within 2GHB, the ICOs received no formal training in IPC. They rely on SOPs that are often vague and don't address the issues of the MTFs.[4] The ICO role is usually secondary to their regular duties. Due to the ICO's lack of expertise and the role being a secondary duty, errors in IPC practices are possible which could lead to an increase in HAIs. By comparison, UK Field Hospitals have dedicated ICOs who report directly to the Hospital Commander. Their IPC program is well established, and in combination with shorter evacuation times from Afghanistan, could account for the lower rates of HAIs in wounded UK personnel.[27] Current practice within the US Army MTFs requires deploying Role 2 and Role 3 MTFs to identify and adequately train their ICO before deployment.[31]

Formal education for the ICOs and continuing education within the MTFs ensures that the IPC is effective during the deployment. Roup and Kelly[32] (p1252) explain that 'the underpinning of a successful IC program is regular education and communication. IPC must be given emphasis and responsible personnel to be successful'. To be effective, the IPC education must be designed for the area of operations the MTF will be operating in and include a range of topics from basic IPC practices to the diseases that are most likely to be observed.[1]

An example where continual education in IPC improves patient outcomes is the education program introduced to reduce the rates of ventilator-associated pneumonia (VAP) and central line-associated bloodstream infection (CLABSI) in a deployed MTF in Iraq from 2006 to 2007.[23] The program reinforced strict adherence to good HH, utilisation of contact precautions when caring for patients with MDROs, staff and patient cohorting, strict AMS and cleaning of the ventilator equipment. Once implemented, the rates of VAP reduced from a baseline of 60 per 1000 device days to 9.7 to 11.6 per 1000 device days.[23] A targeted predeployment program with ongoing education during deployments ensures that the IPC program is monitored and maintained potentially reducing the rates of HAIs.

Correct HH with soap and water or ABHR is crucial in reducing HAIs. Van Camp and Ortega demonstrated that the use of ABHR in a non-deployed military setting reduced the number of lost duty days due to acute illness. They placed ABHR in the buildings of two aviation squadrons in 2005 and reduced the illness rate from 2.4% in 2004 with 210 duty days lost, to 0.9% with a total of 78 duty days lost in 2005.[33] Less than ideal facilities, limited resources and a limited water supply influence HH compliance. Access to ABHR is likely to improve HH compliance.[18] HH compliance monitoring is required within the deployed MTF.[7]

PPE such as gloves, gowns, masks and eye protection need to be used correctly. During the Ebola epidemic in Liberia in November 2014, the Chinese treatment teams implemented a 41-step PPE donning and doffing guide with the requirement for two persons at the don and doff. This ensured that any breaches in the donning and doffing procedure were identified and corrected.[21] Adopting the process ensured that no HCW working within the Ebola Treatment Units (ETUs) became infected with Ebola.[21] While this is an extreme example of correct use of PPE, it does demonstrate that ensuring PPE is used and applied correctly, it can mitigate the risk of transmission of pathogens from the patient to the HCW and vice versa.

Environmental cleaning of the hospital environment is a key element in the IPC program. Surfaces within the hospital that are frequently touched, such as bed rails and bedside tables, act as reservoirs for organisms that can be spread by the hands of the patients, visitors and HCWs. If a room or bed had been occupied by a patient with an MDRO, evidence suggests that subsequent patients are likely to become colonised with the same organism if environmental cleaning is performed incorrectly.[31]

In a recent multicentre controlled trial (REACH) conducted between May 2016 to July 2017, an environmental cleaning bundle was introduced into 11 hospitals around Australia.[31] The bundles provided recommendations on cleaning supplies, frequency and techniques of cleaning, auditing the cleaning process and created a hospital-wide commitment to improving cleaning. As a result, environmental cleaning of frequent touchpoints in hospital bathrooms increased from 55% to 76% and bedrooms from 64% to 86%. Vancomycin-resistant enterococci infections reduced from 0.35 to 0.22 per 10 000 occupied bed days.31 Implementation of these cleaning bundles into the MTFs could potentially reduce the risk of the transmission of MDROs.

Transmission-based precautions within MTFs can be difficult to achieve due to the size and design of the facility. There is often a lack of available single rooms for infected patients. Adequate separation of the patients can be achieved by ensuring there is an area no less than two metres between the patients by having an empty bed between the patients or having the patient area marked off.[1,7,18] Airborne precautions pose a more significant challenge in the deployed environment. Having the isolation ward separate from the main MTF may provide better protection to the other patients and staff.

The overuse of antibiotics in medicine has placed our ability to treat common infectious illness at risk.[35] To reduce the risk of developing further MDROs, AMS should be part of the IPC program.[29] The AMS program reduces the inappropriate use of antimicrobials, reducing bacterial resistance, patient morbidity, mortality and preserving the effectiveness of the antimicrobials currently available.[28] Within Australia, it is a requirement that all healthcare[25] providers have systems in place for the safe and appropriate use and prescribing of antimicrobials.28 Compliance with the AMS program can be achieved with a multidisciplinary approach with daily ward rounds that include the pharmacist, consultants and medical officers.[29] Microbiology support should also be available to provide epidemiology and susceptibility data to direct antimicrobial therapy. For those facilities that do not have access to microbiology support, operating theatre antibiograms should be available to assist in the selection of empirical antimicrobial therapy.[4]

An expert review of the IPC SOPs should be conducted to ensure best practice is being followed and there is consistency of the SOPs across MTFs. Along with the SOPs, clinical practice guidelines (CPGs) specific to the care of combat-related infections can reduce the risk of HAIs and thus reduce morbidity and mortality, improve efficiency, ensure consistency in clinical practice and act as a valuable point of reference for clinicians.[36]

The main limitation of this study is that the articles reviewed are English only and only 13 met the inclusion and quality criteria of the study. Another is that while there is evidence that these interventions can improve IPC outcomes, given the inability to conduct randomised controlled trials of these interventions for ethical reasons (i.e. withholding interventions known to have a positive impact), the degree to which each of these contributes to improved outcomes cannot be determined

## Conclusion

While the principles remain the same, IPC in the deployed MTF comes with a unique set of challenges. To ensure the IPC program is effective, this integrative review has identified four evidence-based overarching strategies/recommendations required.

Specialised training and expertise in IPC for ICOs to provide mandatory education in IPC predeployment (and during deployment) to all deploying HCWs, assist in the development and sustained implementation and evaluation of SOPs and CPGs, and adapt IPC principles to austere environments.

Provision of ongoing IPC education program during deployment with evaluation of practice standards through HAI surveillance.

Development, implementation, and evaluation of SOPs and CPGs for IPC in the MTF that include all aspects of standard and transmission-based precautions.

An AMS program in conjunction with the use of SOPs and CPGs to standardise the care of the patient and reduce the risks of MDROs and HAIs.

Preventing HAIs and limiting the spread of MDROs is the responsibility of all HCWs within the MTF. Establishing good IPC practices and procedures will reduce the risk of HAIs and prevent any further infection-related harm occurring to injured personnel or civilians in their care.

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*Corresponding author: John Skipp*
*john.skipp@defence.gov.au*
*Authors: J Skipp[1,] P Zimmerman[2,3,4,] T Van de Mortel[5]*
*Author Affiliations:*
*1 Australian Army, 2nd General Health Battalion*
*2 Griffith University Griffith Health*
*3 Griffith University Menzies Health Institute Queensland*
*4 Gold Coast Health Service District*
*5 Griffith University, School of Nursing and Midwifery*

## References


1. Vane EA, Winthrop TG, Martinez LM. Implementing basic infection control practices in disaster situations. Nurs Clin North Am. 2010;45(2):219–231.
2. Mitchell BG, Shaban RZ, MacBeth D, et al. The burden of healthcare-associated infection in Australian hospitals: A systematic review of the literature. Infection, Disease & Health. 2017;22(3):117–128.
3. Linwood R, Duff N, Flint C, et al. Application of clinical governance in a role 2E hospital: The 2nd general health battalion experience. J Mil Vet Health. 2017;25(1):23-29.
4. Hospenthal DR, Crouch HK. Infection control challenges in deployed US military treatment facilities. J Trauma. 2009;66(4 Suppl):S120–128.
5. Crouch HK, Murray CK, Hospenthal DR. Development of a deployment infection control course. Mil Med. 2010;175(12):983–989.
6. Merens A, Rapp C, Delaune D, et al. Prevention of combat-related infections: antimicrobial therapy in battlefield and barrier measures in French military medical treatment facilities. Travel Med Infect Dis. 2014;12(4):318–329.
7. Hospenthal DR, Green AD, Crouch HK, et al. Infection prevention and control in deployed military medical treatment facilities. J Trauma. 2011;71(2 Suppl 2):S290–298.
8. Kaspar RL, Griffith ME, Mann PB, et al. Association of bacterial colonization at the time of presentation to a combat support hospital in a combat zone with subsequent 30-day colonization or infection. Mil Med. 2009;174(9):899–903.
9. Tribble DR, Rodriguez CJ. Combat-Related Invasive Fungal Wound Infections. Curr Fungal Infect Rep. 2014;8(4):277–286.
10. Commonwealth of Australia. Australian Army Land Warfare Doctrine LWD 1-2 Health Support 2015. Canberra2015. Figure 1, The Combat Health Operating System; p. 10.
11. The Royal Australian College of General Practitioners. Standards for Garrison Health Facilities in the Australian Defence Force. East Melbourne: The Royal Australian College of General Practitioners; 2015. Available from: https://www.racgp.org.au/FSDEDEV/media/documents/Running%20a%20practice/Practice%20standards/4th%20edition/Standards-for-Garrison-Health-Facilities-in-the-Australian-Defence-Force.pdf.
12. Australian Commission of Safety and Quality in Healthcare [ASCQHC]. National Saftey and Quality Health Service Standards. 2nd ed. Sydney: ACSQHC; 2017.
13. Australian Commission of Safety and Quality in Healthcare. Safety and Quality Improvement Guide Standard 3: Preventing and Controlling Healthcare Associated Infections. Sydney: ACSQHC; 2012.
14. Whittemore R, Knafl K. The integrative review: updated methodology. J Adv Nurs. 2005;52(5):546–553.
15. Souza MTd, Silva MDd, Carvalho Rd. Integrative review: what is it? How to do it? Einstein (São Paulo). 2010;8(1):102-106.
16. Pluye P, Robert E, Cargo M, Bartlett G, O'Cathain A, Griffiths F, Boardman F, Gagnon MP, Rousseau MC. Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. 6 May 2019. Available from: https://learn-ap-southeast-2-prod-fleet01-xythos.s3-ap-southeast-2.amazonaws.com/5bb70f08ac35e/4315522?response-content-disposition=inline%3B%20filename%2A%3DUTF-8%27%27MMAT%25202011%2520criteria%2520and%2520tutorial%25202011-06-29.pdf&response-content-type=application%2Fpdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Date=20190505T224843Z&X-Amz-SignedHeaders=host&X-Amz-Expires=21600&X-Amz-Credential=AKIAIW5OVFIUOTV36DNA%2F20190505%2Fap-southeast-2%2Fs3%2Faws4_request&X-Amz-Signature=fc9bced2ddcc17f7b1dc725db3ecace5387a01bc9743473eef66f4d2bea31d84.
17. Yun HC, Murray CK. Infection prevention in the deployed environment. US Army Med Dep J. 2016;2(16):114–118.
18. Mérens A, Rapp C, Delaune D, et al. Prevention of combat-related infections: Antimicrobial therapy in battlefield and barrier measures in French military medical treatment facilities. Travel Med Infect Dis. 2014;12(4):318–329.
19. Hospenthal DR, Crouch HK, English JF, et al. Response to infection control challenges in the deployed setting: Operations Iraqi and Enduring Freedom. J Trauma. 2010;69 Suppl 1:S94-101.

20. Zheng W, Hu Y, Xin H. Successful implementation of thirty five major orthopaedic procedures under poor conditions after the two thousand and fifteen Nepal earthquake. Int Orthop. 2016;40(12):2469–2477.
21. Liu L, Yin H, Liu D. Zero Health Worker Infection: Experiences From the China Ebola Treatment Unit During the Ebola Epidemic in Liberia. Disaster Med Public Health Prep. 2017;11(2):262–266.
22. Lu Y, Rong G, Yu SP, et al. Chinese military medical teams in the Ebola outbreak of Sierra Leone. J R Army Med Corps. 2016;162(3):198–202.
23. Johnson EN, Marconi VC, Murray CK. Hospital-acquired device-associated infections at a deployed military hospital in Iraq. J Trauma. 2009;66(4 Suppl):S157–163.
24. Currie AJ. H1N1 in the field: The impact on Australian Defence Force Field Exercise Talisman Sabre 09. Australas Emerg Nurs J. 2011;14(2):103–107.
25. Australian Commission on Safety and Quality in Health Care [ACSQHC]. Antimicrobial Stewardship in Australian Health Care. Sydney: ACSQHC; 2018.
26. Fletcher TE, Hutley E, Adcock CJ, et al. Deployed antimicrobial stewardship: an audit of antimicrobial use at Role 3. J R Army Med Corps. 2013;159(3):237–239.
27. Eardley WG, Brown KV, Bonner TJ, et al. Infection in conflict wounded. Philos Trans R Soc Lond B Biol Sci. 2011;366(1562):204–218.
28. Saeed O, Tribble DR, Biever KA, et al. Infection prevention in combat-related injuries. Military medicine. 2018;183(suppl. 2):137–141.
29. Roup B, W Kelley P. Principles of Infection Control and Prevention during Military Deployment 2019. [1249-1266]. Available from: https://www.researchgate.net/publication/265184525_PRINCIPLES_OF_INFECTION_CONTROL_AND_PREVENTION_DURING_MILITARY_DEPLOYMENT.
30. Van Camp RO, Ortega HJ, Jr. Hand sanitizer and rates of acute illness in military aviation personnel. Aviat Space Environ Med. 2007;78(2):140–142.
31. Mitchell BG, Hall L, White N, et al. An environmental cleaning bundle and health-care-associated infections in hospitals (REACH): a multicentre, randomised trial. Lancet Infect Dis. 2019;19(4):410–418.
32. World Health Organization. Global Action Plan on antimicrobial resistance: World Health Organization; 2015. Available from: https://www.who.int/antimicrobial-resistance/publications/global-action-plan/en/.
33. Jun J. Barriers and facilitators of nurses' use of clinical practice guidelines: An integrative review. Int J Nurs Stud. 2016;60:54–68.

# Adjunct Activities for Mental Health Improvement for Veterans

*T Watt, E Kehoe*

Abstract

The disruptive and at times traumatic nature of military service can create mental health issues among veterans. Wounded, injured or ill personnel, even if their physical and psychological rehabilitation goes well, can experience an acute loss of purpose and structure that is provided during their military service, especially post-discharge. It is also increasingly recognised that contemporary veterans have unique requirements, and in this context, military personnel often find their traditional medical and psychological treatments are insufficient to address their needs. Fortunately, there is growing evidence that a range of exercises, such as physical activity as well as animal- and art-based activities can serve as worthwhile adjuncts to more familiar programs of rehabilitation and reintegration. There is growing evidence that these activities reduce anxiety, depression and PTSD symptoms — all of which are relevant to military personnel. The theoretical basis concerning symptom reduction includes behavioural, cognitive and neurophysiological theories. Tests of these theories may result in enhanced treatment. This paper will describe these adjunct activities and how they are being implemented with Australian Defence Force (ADF) personnel, with particular focus on the evidence and theories surrounding art-based endeavours as an adjunct to established therapies.

## Introduction

Military personnel often face abrupt and substantial changes in their lives, which can leave them feeling dislocated. Wounded, injured or ill personnel, even if their physical and psychological rehabilitation goes well, can experience an acute loss of purpose and structure that is provided during their military service. Moreover, should they ultimately discharge, they can face a further loss of meaning as they start to search for a 'new normal'.[1] It is also increasingly recognised that contemporary veterans have unique requirements,[2] and in this context, military personnel often find their traditional medical and psychological treatments are insufficient to address their needs.[3] Fortunately, there is growing evidence that a range of activities can serve as worthwhile adjuncts to more familiar programs of rehabilitation and reintegration, resulting in better engagement[4] and therefore providing new frameworks for enhanced treatment.[5] This paper will describe these adjunct activities and how they are being implemented with Australian Defence Force (ADF) personnel, with particular focus on the evidence and theories surrounding art-based endeavours as an adjunct to established therapies.[6]

The most promising adjunct activities are already widely recognised as being associated with health and wellbeing in everyday life. As distinct from the methods requiring specialised training found in established therapies, these adjunct activities are commonly used by the general public for their intrinsic benefits of skill development, personal expression and enjoyment. As will be described below, there is increasing evidence that these same activities can be safely and effectively incorporated into treatment and rehabilitation programs for anxiety, depression and other psychological challenges.[7]

These activities fall into three broad classes, specifically: exercise, sport and adventure; contact with animals; and art-based endeavours. Across the Australian Department of Veterans Affairs (DVA), ADF and various ex-service organisations, these activities are being implemented or considered for contemporary veterans. The potential benefits of such activities might be taken for granted in the general public, yet the empirical and theoretical underpinnings of the activities are still being ascertained. In particular, it remains to be determined what underlying mechanisms contribute to their positive outcomes, and whether the outcomes have enduring benefits.

The following sections of this paper will address three main questions about adjunct activities:

- First, what are the adjunct activities? There will be brief descriptions of physical exercise, animal-related activities and creative art-based activities that may already be familiar to this journal's readers. A longer description will be devoted to the use of art-based endeavours by wounded, injured or ill veterans in both the ADF and elsewhere.

- Second, what are the adjunct activities good for? The answer to this question includes a description of the empirically-demonstrated positive benefits of adjunct activities and how they supplement standard programs of treatment and rehabilitation, especially for psychological challenges that veterans often face.
- Third, how do the adjunct activities work? The answer to this question concerns the behavioural, cognitive and neurophysiological mechanisms that may underpin the effectiveness of adjunct activities. Understanding these mechanisms should assist the further refinement of the adjunct activities and their integration with standard programs of treatment and rehabilitation.

## Adjunct activities

### Exercise, sport and adventure

The value of physical activity in the form of personal exercise, sport and adventurous training in the wellbeing of veterans has been most prominently demonstrated through the increasing use of competitive activities. The Invictus Games is one such international program in which multiple nations send wounded military personnel to an annual event to improve their recovery and rehabilitation. Another example of physical activities open to veterans is surfing, which can be adapted readily to many circumstances.[8] It can be pursued as either individual recreation or competitive sport. Surfing shares with adventurous training its setting in nature combined with a degree of controlled risk. Moreover, key aspects of surfing, such as the patience needed to wait for a wave, the instantaneous thrill, the demands of absorption required to stay on a wave and the connection with the untamed ocean[9] share broad similarities with the challenges of outdoor military activities. These similarities are then used through therapy to develop greater confidence and better coping skills for day-to-day challenges. The United States Marine Corps in conjunction with the University of Southern California has evaluated a surfing program which has yielded the desired benefits to wellbeing and PTSD symptoms of participating veterans.[10]

## Animal-based activities

Since ancient Greece, the use of animals has been associated with improving general wellbeing.[11] Following World War I, service dogs were used as aids for those with visual impairments and other sensory limitations. More recently, a new role for canines has seen the development of companion dogs for people with mental health challenges. The use of dogs in this manner has gained preliminary support for benefiting veterans through stress reduction, companionship and lifting of mood.[12] The American Veterans Administration (VA) has commenced a study into the benefits of companion dogs[13], and the Australian DVA, while not yet funding companion dogs, is monitoring research on the use of dogs for companionship and practical assistance in the therapy and rehabilitation of veterans.[14]

In addition to dogs, the use of horses as an adjunct activity has been developing for some time.[15] The main benefit of using horses is through their sensitivity to human cues. A horse can respond dramatically to behavioural cues thus providing an individual with feedback on their own behaviour.[16] By constantly testing and adjusting behaviours as a reaction to the horse's behaviour, individuals learn to cope with their mental health symptoms. Due to the imposing nature of horses, the responses they provide, such as backing off to aggressive behaviours or crowding when submissive behaviours are displayed, may prompt individuals to be more mindful of their own behaviours.[15]

## Creative art-based activities

The creation of art-based activities through *inter alia,* painting, drawing, music, writing and dramatic performance has been long recognised as potentially beneficial for people undergoing therapy and rehabilitation.[17] For veterans in America and Great Britain, theatre activities supported by government and military departments have been used over the past several years as an adjunct to standard therapies.[18] In particular, the language in the war-related plays of Shakespeare has provided veterans an appropriate distance in which to engage in therapeutic theatre involving elements of mindfulness, camaraderie and increased self-awareness.[19] Australian military personnel and veterans have been part of several art-based endeavours using theatre as a medium for improvement. An adaptation of a Canadian theatre-based program was found to provide confidence and optimism to Australian Veterans, through safely processing traumatic events from different perspectives.[20] Generally regarded as a success, the ADF adopted theatre production as a potentially useful means for assisting wounded, injured or ill veterans in their recovery and rehabilitation. The 2014 pilot project — The ADF Theatre Project — featured a professionally-written play, centred on the stories of the cast members, most of whom themselves were wounded, injured or ill veterans. The ADF in conjunction with the Sydney Theatre Company produced 'The Long Way Home', which toured nationally and received acclaim from critics and audiences. Informal discussions with the cast members revealed that they highly valued the opportunity to be part of a team again and tell their stories with the aim of increasing public awareness of the achievements, sacrifices and challenges faced by returning veterans.

As a functional and sustainable model for the adjunct use of the creative arts, the ADF has developed a program called the Art for Resilience, Recovery and Teamwork Skills (ARRTS). It is a four-week program that for the past four years has been conducted bi-annually. The ADF ARRTS program is a non-clinical, creative art-based program that can comprise of up to four streams — visual arts; creative writing; music and rhythm; and acting and performance. The program is overseen by university academics and other specialists with training in the arts in an on-campus arts facility. The program is currently undergoing formal evaluation.

## Do adjuncts to traditional therapies really work?

The following section outlines the specific psychological benefits for of adjunct activities.

### Exercise, sport and adventure

It has long been established that physical exercise reduces depressive symptoms, with newer research focusing on the improvements that exercise has on quality of life.[21] More specifically, exercise has reliable positive outcomes regardless of what may have caused the depressive symptoms. A meta-analysis of 25 randomised control trials revealed a large mean-effect size in reducing depressive symptoms, specifically 1.11 standard deviations units ($d$)[21]. Among veterans, physical activity is associated with a small but significant reduction in depression and adverse somatic symptoms (inverse odds ratios = 0.96, 0.93) such as back pain, headaches, sleep disturbance and fatigue.[22] In contrast, anxiety and stress-related symptoms are not discernibly lessened by exercise.[23]

An optimum range of exercise for general mental health was found to exist between 2.5 to 7.5 hours per week,[24] and that sports/physical activity in natural environments have a greater impact on improvements than non-natural environments.[25] Furthermore, different forms of physical activity are variably associated with self-reported mental health.[26] In particular, participation in sports has been associated with small, but significant decreases in distress as measured by the General Health Questionnaire (mean inverse odds ratio = 0.45). In contrast, other physical activities such as walking and bicycling are associated with increases in stress (odds ratio = 1.953).[26]

### Animal-based activities

Among civilian populations, a systematic review of studies using research designs ranging from staff surveys through pre-post designs to a randomised control trial led the reviewers to conclude that an animal-based adjunct activity to be acceptable and useful in providing relaxation, increasing happiness, reducing anxiety and increasing one-year survival following a cardiac event.[12] Of particular note, animal-based activities produce increases in the biomarker immunoglobin, which does not rely on an individual having an initial positive attitude towards the animals.[27]

Equine therapy, which relies on a horse's response to cues from the human individual, has been found to be beneficial for reducing anxiety and post-traumatic stress-related disorders,[15] as well as reducing biological indicators of stress such as cortisol levels.[28] For example, six, two-hour sessions with horses produced medium to large reductions in posttraumatic stress symptoms ($d$ = 1.21), severe emotional responses to trauma ($d$ = 0.60), generalised anxiety ($d$ = 1.01), symptoms of depression ($d$ = 0.54) and alcohol use ($d$ = 0.58).[15] However, physical health, proactive coping, self-efficacy, social support and life satisfaction appeared to be unaffected.

## Creative art-based activities

In contrast to the foregoing evaluations of the therapeutic effect of adjunct sports-based and animal-based activities, comparable evaluations of the impact of art-based activities are in short supply.

While exercise and animal-based therapies have a demonstrated selective impact on, respectively, depression and anxiety, art-based activities are to have a broader impact reducing both anxiety and depressive symptoms. The clinical disorders that are claimed to benefit from art-based activities include PTSD,[29] anxiety,[30] and depression.[31] Beyond remediation of mental health disorders, art-based activities are also claimed to increase both resilience and a sense of belonging,[32] two factors that are particularly pertinent within the military. Despite these claims being widespread, there has also been an identified risk that the results may be contaminated by a confirmatory bias[17] and in some cases, the use of unreliable measurement methods.

Repeated searches of the literature have indicated that rigorous evaluations of art-based activities are in short supply. Three relevant studies have appeared. First, in a nonclinical laboratory setting, university studies underwent a stress-inducing mental arithmetic task and a Stroop Color and Word interference task. The students then engaged in either creative drawing or a non-artistic map-reading task. The drawing task produced medium-sized reductions in stress relative to the non-artistic task ($r$ =.31) [33] In the second and third studies, US veterans undergoing Cognitive Processing Therapy (CPT) for combat-associated PTSD were randomised into a group that, in addition to their CPT sessions, received art therapy sessions specifically aimed at using drawing and collage in the processing of the patient's visual trauma narrative and symptoms.[34,35] Over eight sessions of treatment, the results of the two studies were mixed. In one study (N = 31) but not in a smaller pilot study (N=11), patients in the art therapy groups showed a large-effect reduction in symptoms measured by PCL-M and Beck Depression Inventory relative to a control group of patients that continued to receive only CPT.[34,35]

## The underlying mechanisms

Like so many developing areas of health, there is a diverse number of theories concerning the mechanisms through which adjunct activities may achieve beneficial effects. There are, in fact, three main branches of theory-oriented to behavioural, cognitive and neurophysiological mechanisms underpinning the positive influence of adjunct activities.

### Behavioural activation theory

Recently, a new method of therapy has been identified for treating depression. Behavioural activation aims to assist a patient in developing psychologically meaningful activities for identifying their place in the world.[36] This method is targeted at reducing a patient's sense of isolation from their identity, family, friends and society. According to this theory, scheduling meaningful activities and skills training[37] provides a sense of purpose, enjoyment and mastery. Similarly, the same activities are thought to promote increases in a sense of personal accomplishment, self-esteem and social connection.[38] While behavioural activation is being recognised as an effective treatment, it currently consists of a basket of multiple elements rather than a precisely-defined set of procedures.[36]

### Cognitive theories

**Sense of belonging** — Central to theories of effectiveness and resilience of soldiers in combat is the role played by cohesiveness and belonging in small groups.[39] Similarly, a sense of belonging in a small analysis of veterans post-deployment has been found to protect against PTSD and depressive symptoms.[40] There is evidence that different types of service, such as part-time, can reduce a sense of belonging,[41] leading to an increased risk of mental health disorders such as PTSD and susceptibility to suicide.[42] More generally, a consistent sense of belonging with family, friends, small groups and colleagues may have far-reaching implications for the mental health of veterans both during and following service. When veterans perceive dissonance between their civilian and military cultures, they feel alienated from friends and family, reducing their sense of identity, leading to feelings of distress.[43] For mental health disorders such as depression and anxiety, both have symptoms of social isolation as core components.[44] However, belonging is part of a multifaceted concept, which may include a person's sense of physical place as well as their place in a group.[45] Hence, in evaluating any therapy's effect in alleviating symptoms associated 0with perceived isolation, it may be worthwhile to ascertain its effects on the person's sense of belonging in a place as well as in a group.[46]

**Cognitive flow** — Flow is commonly described as living in the present including the ability to become fully immersed in an activity with a feeling of energised focus and enjoyment, potentially losing a sense of space and time.[47] Flow has been discussed in the context of combat.[48] One notable instance was reported in the book *Black Hawk Down* where a soldier compared flow in combat to a similar sensation in surfing.[49] Flow has been theorised as an underlying mechanism in art-based activities, possibly leading to the positive outcomes in art therapy.[50] In either case, activities that produce this state may be connected to the relief of debilitative anxiety.[30] Along similar lines, absorption in an activity can enhance the levels of satisfaction from an optimal challenge and can increase belief in competence, thus influencing the enjoyment of activities.[51] However, the concept of flow and its supporting findings have recently been the subject of criticism contending, among other things, that there is a lack of theoretical and empirical consensus regarding the number and/or combination of dimensions required to classify a flow state.[52]

**Therapeutic alliance** — Beyond the specific features of therapeutic interventions, a set of factors around the relationship between a client and therapist may contribute to therapeutic success.[53] The most widely studied common factor is the 'alliance' between therapist and patient.[54] This alliance is a bundle of three components: the bond of mutual trust and connection, agreement about the goals of therapy and agreement about the tasks of therapy. Similarly, the bond of mutual trust and connection are consistent with the core values and behaviours of the Australian Navy, Army and Air Force. Meta-analysis of multiple findings has revealed that alliance has a medium-sized positive effect.[53] In addition, the ability of a therapist to empathise with a patient has been experimentally demonstrated to improve therapeutic success.[55] In meta-analytic studies, empathy has small positive effects on outcomes.53 A third factor that has a small positive effect entails the patient's expectations about the consequences of engaging in therapy.[53] While the effects are not large, recent research has highlighted the known effect of therapeutic alliance in art-based activities but also, in that context, the need for well-validated measures of the therapeutic alliance.[56]

**Core self-evaluations** — A higher-order dispositional trait comprised of locus of control, neuroticism, self-efficacy and self-esteem — called an individual's core self-evaluations — has been proposed as influential for an individual's effectiveness in the workplace.[57] This trait, when viewed as one nomological network, demonstrated greater predictive validity for job behaviours than when each trait was used in isolation.[58] A person's core self-evaluations have been found to be one of the best predictors for job performance and job satisfaction[57] and have been linked to improved goal setting.58 In a therapeutic context, core self-evaluations may be associated with therapeutic success and general wellbeing. In turn, adjunct activities may increase an individual's core self-evaluations; however, the challenge at this stage is the absence of published evidence for the effect of this trait in the context of adjunct therapies.

### Neurophysiological theories

There are various theories related to neurophysiological changes in the body. As outlined below, some of these theories have been supported by measurable changes in hormones and other biomarkers. Such evidence is compelling and, to a limited extent, has been demonstrated in the context of adjunct activities.

**Endorphin release mechanisms** — Depression has been hypothesised to be linked to the pain system being activated when someone is in stress.[59] The way exercise could influence the pain system, is through the positive outcomes associated with endorphins being released post-exercise. Therefore, those who associate exercise with feeling better will be encouraged further to use it to reduce depression and improve their overall health.[60] Likewise, pleasurable interactions with animals have also been thought to produce endorphin release leading to associations with relaxation and safety that in turn reduce at least some aspects of the PTSD symptomology.[61]

**Neurological theory** — At a neurological level, exercise and stress have opposing effects on the encoding of memories. In particular, the physical fitness resulting from exercise reduces interference in the manner in which memories are encoded.[62] Service in the military requires maintenance of physical fitness,[63] and ongoing exercise regimes could be a protective factor for memory-based disorders. This encoding effect could be an important factor for the veteran community who generally experience stress in combat while they are physically fit, thus possibly creating a protective factor.

**Physiological mechanisms** — When people with a mental illness have been in contact with animals, evidence of a positive effect has been gathered via a change in biomarkers such as cortisol, epinephrine, norepinephrine and blood pressure.[64] These effects are theorised to occur via the underlying oxytocin system.[65] Benefits of animal contact have also been attributed to the action of mirror neurons, whereby a patient involuntarily mimics the positive attitude of an animal in the therapeutic regime.[66] Although no studies concerning art therapy have been conducted with clinical and/or military populations, art therapy has been found to reduce cortisol levels and state anxiety among employees under ordinary occupational stress.[67]

## Conclusions

Adjuncts to traditional therapies rely on theories or mechanisms that integrate well-researched therapies with less well-tested adjunct activities to improve therapeutic outcomes. The various theories and mechanisms described in this review are still subject to ongoing research and development allowing us to better understand how they contribute to therapeutic outcomes. However, for developing and testing adjunct therapy, especially art-based activities, there are at least two impediments. First, art-based activities are not well defined. They occupy a broad spectrum of behavioural treatments ranging from recreation and leisure to therapeutic and supportive programs, as well as formalised therapy and psychotherapy.[68,69] Second, some advocates of art therapy fear that the development of well-defined formulated interventions will compromise the free-form, expressive intent of art and will ultimately diminish its effectiveness.[69,70]

As to be expected, with a relatively new area of research, there is a high proportion of qualitative data being collected which can be expected to inform future quantitative data collection.[45] Discussion around research methods and lack of validated measures continues.[71,72] The theoretical concepts while being tested in a variety of settings are largely observational and are yet to be researched using large randomised control trials.[72] Where they have recently been used, they are small-scale studies.[35] Even from proponents of adjunct activities, there is a wariness that the lack of data remains problematic.[73]

Adjunct activities through their everyday enjoyment and ease of access are being increasingly used by veteran populations. There is growing evidence that these activities reduce anxiety, depression and PTSD symptoms — all of which are relevant to military personnel. The theoretical bases concerning symptom reduction include behavioural, cognitive and neurophysiological mechanisms. Regarding veterans as a special population, it remains to be determined which of the theoretical mechanisms is most relevant to their needs. Moreover, which characteristics of veterans might make them particularly suitable for different adjunctive activities also remain to be determined.

The increasing evidence base has led the ADF to develop the ADF ARRTS program — a sustainable art-based training intervention that so far has seen over 190 participants complete and present their art-based endeavours to their families, supporters and the senior leadership of the ADF. This program goes beyond good intentions and actively engages with subject matter experts in the arts and health to holistically support veterans on their path to recovery and reintegration in their communities.

The future of this endeavour and others like it will require further research for three purposes: first, for developing an evidence base documenting the improvements in the wellbeing of military personnel in the ARRTS program; second, for uncovering which theoretical mechanisms best explain how an arts-based program leads to improvement in mental health; and thirdly, to test whether the effects are enduring.

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### Statement of Conflict of Interests

MAJ Watt is currently a reservist officer in the Australian Army and receives normal wages for his current duties in the ADF ARRTS program.

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*Corresponding Author: Tavis Watt,*
*tavis.watt@student.unsw.edu.au*
*Authors: T Watt[1,2], E Kehoe[1]*
*Author Affiliations:*
*1 University of NSW, School of Psychology*
*2 Australian Army*

## References

1. Ahern J, Worthen M, Masters J, Lippman SA, Ozer EJ, Moos R. The challenges of Afghanistan and Iraq veterans; transition from military to civilian life and approaches to reconnection. PLoS ONE. 2015;10(7):<xocs:firstpage xmlns:xocs=""/>.
2. DVA. Veteran Mental Health Strategy 2013. In: Affairs DoV, ed. Canberra: Commonwealth of Australia; 2013.
3. Jennings KS, Zinzow HM, Britt TW, Cheung JH, Pury CLS. Correlates and reasons for mental health treatment dropout among active duty soldiers. Psychological Services. 2016;13(4):356–363.
4. Kahl K, Winter L, Schweiger U. The third wave of cognitive behavioural therapies: what is new and what is effective? Current Opinion in Psychiatry. 2012;25(6):522.
5. Zinzow HM, Britt TW, Pury CLS, Jennings K, Cheung JH, Raymond MA. Barriers and facilitators of mental health treatment-seeking in U.S. active duty soldiers with sexual assault histories. Journal of Traumatic Stress. 2015;28(4):289–297.
6. DeLucia JM. Art therapy services to support veterans' transition to civilian life: The studio and the gallery. Art Therapy: Journal of the American Art Therapy Association. 2016;33(1):4–12.

7. Wilson C, Bungay H, Munn-Giddings C, Boyce M. Healthcare professionals' perceptions of the value and impact of the arts in healthcare settings: A critical review of the literature. International Journal of Nursing Studies. 2015;56:90–101.
8. Caddick N, Smith B, Phoenix C. The effects of surfing and the natural environment on the well-being of combat veterans. Qualitative health research. 2015;25(1):76.
9. Diehm R, Armatas C. Surfing: an avenue for socially acceptable risk- taking, satisfying needs for sensation seeking and experience seeking. Pers Individ Differ. 2004;36(3):663–677.
10. Rogers CM, Mallinson T, Peppers D. High-intensity sports for Posttraumatic Stress Disorder and Depression: Feasibility study of ocean therapy with veterans of Operation Enduring Freedom and Operation Iraqi Freedom. Am J Occup Ther. 2014;68(4):395–404.
11. Willis DA. Animal therapy. Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses. 1997;22(2):78.
12. Halm MA. The healing power of the human-animal connection. American Journal of Critical Care. 2008;17(4):373–376.
13. U.S.DVA. Dogs and PTSD. U.S. Department of Veterans Affairs. https://www.ptsd.va.gov/public/treatment/cope/dogs_and_ptsd.asp. Published 2015. Accessed 12/4/2018, 2018.
14. Affairs DoV. Assistance dogs. Department of Veterans Affairs. https://www.dva.gov.au/health-and-wellbeing/rehabilitation/assistance-dogs. Published 2018. Accessed 12/4/18, 2108.
15. Earles JL, Vernon LL, Yetz JP. Equine-assisted therapy for anxiety and posttraumatic stress symptoms. Journal of Traumatic Stress. 2015;28(2):149–152.
16. Proops L, McComb K. Attributing attention: The use of human-given cues by domestic horses (Equus caballus). Anim Cogn. 2010;13(2):197–205.
17. Uttley L, Stevenson M, Scope A, Rawdin A, Sutton A. The clinical and cost effectiveness of group art therapy for people with non- psychotic mental health disorders: A systematic review and cost-effectiveness analysis. BMC Psychiatry. 2015;15(1).
18. The-Royal-British-Legion. Bravo-22-Company. The Royal British Legion. Published 2018. Accessed 13/4/2018.
19. Howes R. Theater as therapy: Can Shakespeare heal the trauma of war? Psychotherapy Networker. 2019;43(1):59–61.
20. Balfour M, Westwood M, Buchanan MJ. Protecting into emotion: therapeutic enactments with military veterans transitioning back into civilian life. Research in Drama Education: The Journal of Applied Theatre and Performance. 2014;19(2):1–17.
21. Schuch FB, Vancampfort D, Rosenbaum S, Richards J, Ward PB, Stubbs B. Exercise improves physical and psychological quality of life in people with depression: A meta- analysis including the evaluation of control group response. Psychiatry Research. 2016;241:47–54.
22. Hoerster KD, Jakupcak M, McFall M, Unützer J, Nelson KM. Mental health and somatic symptom severity are associated with reduced physical activity among US Iraq and Afghanistan veterans. Preventive medicine. 2012;55(5):450.
23. Bartley CA, Hay M, Bloch MH. Meta- analysis: Aerobic exercise for the treatment of anxiety disorders. Progress in neuro-psychopharmacology & biological psychiatry. 2013;45:34.
24. Kim YS, Park YS, Allegrante JP, et al. Relationship between physical activity and general mental health. Preventive medicine. 2012;55(5):458.
25. Mitchell R. Is physical activity in natural environments better for mental health than physical activity in other environments? Social Science & Medicine. 2013;91:130.
26. Asztalos M, Wijndaele K, De Bourdeaudhuij I, et al. Specific associations between types of physical activity and components of mental health. Journal of Science and Medicine in Sport. 2009;12(4):468–474.
27. Charnetski CJ, Riggers S, Brennan F. Effect of petting a dog on immune system function. Psychol Rep. 2004;95(3):1087-1091.
28. Yorke J, Nugent W, Strand E, Bolen R, New J, Davis C. Equine- assisted therapy and its impact on cortisol levels of children and horses: a pilot study and meta- analysis. Early Child Development and Care. 2012:1–21.

29. Smith A. A literature review of the therapeutic mechanisms of art therapy for veterans with post-traumatic stress disorder. International Journal of Art Therapy. 2016;21(2):66–74.
30. Kapitan L. Art therapy's sweet spot between art, anxiety, and the flow experience. Art Therapy. 2013;30(2):54–55.
31. Blomdahl, Gunnarsson BA, Guregård S, Rusner M, Wijk H, Björklund A. Art therapy for patients with depression: Expert opinions on its main aspects for clinical practice. Journal of mental health (Abingdon, England). 2016;25(6):527.
32. Macpherson H, Hart A, Heaver B. Building resilience through group visual arts activities: Findings from a scoping study with young people who experience mental health complexities and/or learning difficulties. Journal of Social Work. 2016;16(5):541–560.
33. Abbott KA, Shanahan MJ, Neufeld RWJ. Artistic tasks outperform nonartistic tasks for stress reduction. Art Therapy: Journal of the American Art Therapy Association. 2013;30(2):71–78.
34. Campbell M, Decker KP, Kruk K, Deaver SP. Art Therapy and Cognitive Processing Therapy for Combat-Related PTSD: A Randomized Controlled Trial. Art Therapy. 2016;33(4):169–177.
35. Decker KP, Deaver SP, Abbey V, Campbell M, Turpin C. Quantitatively Improved Treatment Outcomes for Combat-Associated PTSD With Adjunctive Art Therapy: Randomized Controlled Trial. Art Therapy. 2018:1–11.
36. Kanter JW, Manos RC, Bowe WM, Baruch DE, Busch AM, Rusch LC. What is behavioral activation?. A review of the empirical literature. Clinical Psychology Review. 2010;30(6):608–620.
37. Soucy Chartier I, Provencher MD. Behavioural activation for depression: Efficacy, effectiveness and dissemination. Journal of Affective Disorders. 2013;145(3):292–299.
38. Kopytin A, Lebedev A. Humor, self-attitude, emotions, and cognitions in group art therapy with war veterans. Art Therapy: Journal of the American Art Therapy Association. 2013;30(1):20–29.
39. Wessely S. Twentieth-century theories on combat motivation and breakdown. Journal of Contemporary History. 2006;41(2):269–286.
40. Bryan CJ, Heron EA. Belonging protects against post deployment depression in military personnel. Depression and Anxiety. 2015;32(5):349–355.
41. Podlogar MC, Houtsma C, Khazem LR, et al. The associations between Army National Guard versus Active Duty Soldier status and perceived burdensomeness, thwarted belongingness, and acquired capability. Journal of Clinical Psychology. 2017;73(12):1682–1691.
42. Joiner TE, Silva C. Why people die by suicide: Further development and tests of the interpersonal-psychological theory of suicidal behavior. American Psychological Association; 2012.
43. Demers A. When veterans return: The role of community in reintegration. Journal of Loss & Trauma. 2011;16(2):160.
44. APA. Diagnostic and Statistical Manual of Mental Disorders. Vol 5. Washington, DC2013.
45. Doroud N, Fossey E, Fortune T. Place for being, doing, becoming and belonging: A meta-synthesis exploring the role of place in mental health recovery. Health & Place. 2018;52:110.
46. Breslau J, Setodji CM, Vaughan C. Is cohesion within military units associated with post- deployment behavioral and mental health outcomes? J Affect Disord. 2016;198:102–107.
47. Harmat Ls, Ørsted Andersen F, Ullén F, Wright J, Sadlo G, Ebooks C. Flow experience: Empirical research and applications. Switzerland : Springer; 2016.
48. Harari Y. Combat flow: Military, political, and ethical dimensions of subjective well-being in war. Rev Gen Psychol. 2008;12(3):253–264.
49. Bowden M. Black Hawk Down. In. London: London : Corgi; 2000.
50. Chilton G. Art therapy and flow: A review of the literature and applications. Art Therapy. 2013;30(2):64–70.
51. Abuhamdeh S, Csikszentmihalyi M. Attentional involvement and intrinsic motivation. Motivation and Emotion. 2012;36(3):257–267.
52. Swann C, Piggott D, Schweickle M, Vella SA. A Review of Scientific Progress in Flow in Sport and Exercise: Normal Science, Crisis, and a Progressive Shift. Journal of Applied Sport Psychology. 2018;30(3):249–271.

53. Wampold BE. How important are the common factors in psychotherapy? An update. World Psychiatry. 2015;14(3):270–277.
54. Stamoulos C, Trepanier L, Bourkas S, et al. Psychologists' perceptions of the importance of common factors in psychotherapy for successful treatment outcomes. Journal of Psychotherapy Integration. 2016.
55. Kaptchuk TJ, Kelley JM, Conboy LA, et al. Components of placebo effect: Randomised controlled trial in patients with irritable bowel syndrome. BMJ : British Medical Journal. 2008;336(7651):999.
56. Bat Or M, Zilcha-Mano S. The Art Therapy Working Alliance Inventory: the development of a measure. International Journal of Art Therapy. 2018:1–12.
57. Judge TA, Locke EA, Durham CC, Kluger AN. Dispositional effects on job and life satisfaction: The role of core evaluations. Journal of Applied Psychology. 1998;83(1):17–34.
58. Erez A, Judge TA. Relationship of core self- evaluations to goal setting, motivation, and performance. J Appl Psychol. 2001;86(6):1270–1279.
59. Balchin R, Linde J, Blackhurst D, Rauch HL, Schönbächler G. Sweating away depression? The impact of intensive exercise on depression. Journal of affective disorders. 2016;200:218.
60. Kvam S, Kleppe CL, Nordhus IH, Hovland A. Exercise as a treatment for depression: A meta- analysis. Journal of Affective Disorders. 2016;202:67–86.
61. Geist TS. Conceptual framework for animal assisted therapy. Child and Adolescent Social Work Journal. 2011;28(3):243–256.
62. Dery N, Pilgrim M, Gibala M, et al. Adult hippocampal neurogenesis reduces memory interference in humans: Opposing effects of aerobic exercise and depression. Front Neurosci. 2013;7.
63. Department_of_Defence. Physical Fitness Standards. http://www.defence.gov.au/ADFA/Training/PhysicalFitness.asp. Published 2017. Accessed 17/10/17, 2017.
64. Marcus D. The science behind animal-assisted therapy. In. Curr. Pain Headache Rep. Vol 172013.
65. Beetz A, Uvnas-Moberg K, Julius H, Kotrschal K. Psychosocial and psychophysiological effects of human- animal interactions: The possible role of oxytocin. In. Front. Psychol. Vol 32012.
66. Baird AD, Scheffer IE, Wilson SJ. Mirror neuron system involvement in empathy: A critical look at the evidence. Social Neuroscience. 2011;6(4):327–335.
67. Visnola D, Sprudza D, Arija M, Pike A. Effects of art therapy on stress and anxiety of employees. Proceedings of the Latvian Academy of Sciences. 2010;64(1–2):85.
68. Kalmanowitz D, Potash J. Ethical considerations in the global teaching and promotion of art therapy to non-art therapists. Arts Psychother. 2010;37(1):20–26.
69. Potash JS, Mann SM, Martinez JC, Roach AB, Wallace NM. Spectrum of art therapy practice: systematic literature review of art therapy, 1983–2014. Art Therapy. 2016;33(3):119–127.
70. Vick RM, Sexton-Radek K. Community-Based Art Studios in Europe and the United States: A Comparative Study. Art Therapy. 2008;25(1):4–10.
71. Cristina C, Aneta F. How can we improve the existing assessments used in arttherapy. A meta-analysis on art therapy assesments. In. Vol 332012:358–362.
72. Rose S, Aiken A, McColl MA. A scoping review of psychological interventions for PTSD in military personal and veterans. Military Behavioral Health. 2014:00–00.
73. Caddick N, Smith B. Exercise is medicine for mental health in military veterans: a qualitative commentary. Qualitative Research in Sport, Exercise and Health. 2018;10(4):429–440.

# Measles Mortality in the Armies of the Early 20th Century

*G D Shanks*


## Abstract

Measles remained a lethal infection during the early 20th century within the military but mortality disappeared prior to immunisation 50 years later. Historical records were reviewed to understand this transition. Measles mortality in soldiers was largely (>80%) due to secondary bacterial pneumonia but this could be highly seasonal, as seen in US Army recruits at Columbus Barracks 1911–13. The UK Highland Division had a lethal (65 deaths / 529 cases, 12%) measles epidemic 1914–15 but this was highly variable within different battalions. The Australian Imperial Force 1914–18 experienced 103 measles deaths (1.5% case fatality rate) half of which occurred in Australia before deployment. Measles remains highly pathogenic and absence of adult mortality cannot be guaranteed if immunisation rates are not maintained or antibiotic-resistant bacteria continues to spread. The Australian Defence Force must be prepared to deal with measles during possible humanitarian assistance missions despite anti-vaccine propaganda.


> *'In our camps deaths due to noncomplicated measles were exceedingly rare; indeed, we are not certain that there were any.'*
>
> *Victor Vaughn 1922*[1]

Measles is a highly transmittable *morbillivirus*, which, until recently, had been considered a good candidate for global elimination as it only infects humans. Successful elimination of measles from much of the developed world has resulted in falling immunisation rates especially after the measles vaccine was incorrectly associated with autism by various anti-vaccine campaigners. The fact that measles continues to kill >100 000 children each year, largely in sub-Saharan Africa, has been ignored as measles morphs into a minor infection with a funny rash in the imagination of many uninformed adults who have never seen the disease. Measles was a major military problem in the previous century as newly recruited civilians often developed measles when gathered in large military training camps. It was a major cause of death during World War I in the Australian Imperial Force (AIF) and only faded as a military problem when globalisation markedly decreased the numbers of adults who had not been infected as children. Measles immunisation since the 1960s largely eliminated it as a public health concern except for some isolated Pacific Island populations. In the early part of the current century, about one hundred cases of measles were reported annually in Australia, usually as imported cases in those who had not been sufficiently immunised as children. Unfortunately, this public health victory is in danger of being reversed such that military medical officers need to be aware of the possibility of measles as a lethal infection. The military history of measles is reviewed to remind physicians who have never seen measles why it could be important to military preventive medicine.

Measles was a highly lethal infectious disease during the US Civil War killing 4246 Union soldiers with countless others dying within the Confederacy. Case fatality rates ranged from 6% in white soldiers to 11% in black soldiers.[2] Postwar measles was mostly a problem in the recruit camps and an extended epidemic occurred from 1910–1912 within Columbus Barracks, Ohio with the continuous selection of the 1–3% largely rural recruits not yet immune to measles (See Figure 1). Measles was not remarkably lethal (5% case fatality rate overall) except during February and March when other respiratory infections were common resulting in secondary bacterial pneumonia.[3] Despite heroic attempts at early detection and isolation, measles infections were nearly continuous in a camp that was progressively introducing new recruits into a larger camp population.

Columbus Barracks accurately predicted the nature but not the scale of what happened during World War I when the USA suddenly recruited not hundreds but millions of men into the army. Measles was unquestionably the greatest infectious disease problem of the US Army in 1917 killing more than 3000 soldiers during the war although its impact was

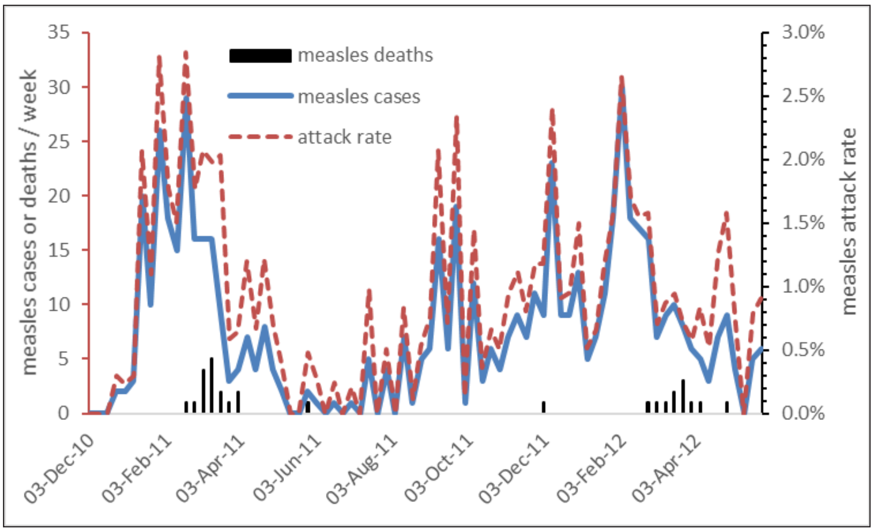


*Figure 1: Measles cases, deaths and attack rates as per cent of recruit population of US Army Columbus Barracks, Ohio 1911–1913 showing the mortality was largely limited to February / March despite near-continuous chain of infection over two years.*

later obscured by the 1918 influenza pandemic.[4] The measles virus attacked the respiratory epithelium but the real risk was that the compromised pulmonary defences of the immunosuppressed soldier would succumb to a secondary infection when respiratory bacteria descended into the lungs to cause pneumonia. Pneumococcus was common but the most lethal pneumonia was caused by what is now called *Streptococcus pyogenes* and in the preantibiotic era had a 1:3 mortality rate. Although nearly all measles susceptible recruits would be infected after joining the army, the rates of secondary bacterial pneumonia and thus death varied greatly with measles-attributed mortality ranging from 0 to 2.4 / 1000 men in 39 different recruit camps during 1917–1918.[1]

This was a puzzling lack of uniformity given the near-identical nature of the camps and was based on the risk not of measles, but secondary bacterial pneumonia. It proved a prescient forerunner of what was to occur during the 1918 influenza pandemic. Men who stayed in their barracks rather than crowded hospital wards or those who were triaged to different wards based on bacterial cultures of their throat had much lower bacterial pneumonia rates post-measles infection.[4] When Cummings (1921) examined the differences between US soldiers developing measles in the USA as opposed to those developing measles after deployment to Europe, he found that although the attack rates were much higher in the recruit camps (29.3 USA vs 6.8 Europe / 1000 soldiers) the measles case fatality rate was much higher in Europe (2.4% USA vs 4.6% Europe).[5] He concluded that the risk of secondary bacterial pneumonia was highest when a soldier with measles was exposed to a large group of 'seasoned' or experienced soldiers who were presumably more likely to have a wide variety of respiratory bacteria and thus available to infect the vulnerable man with measles infection. This fits well with the observation by Vaughn that begins this paper that the men died not of measles but bacterial pneumonia following the viral infection.[1]

Measles in the British Army of World War I was largely confined to men from rural areas typical of the Scottish Highlands who were mobilised as part of the Territorial Army. The Highland Division (51st Division) experienced a measles epidemic after it was concentrated in Bedford for training before its deployment to the Western Front (See Figure 2).[6] The measles infection rates varied widely by battalions within the division and was largely determined by whether the soldiers came from urban Edinburgh or rural Dumfries. Battalions with high measles rates did not necessarily have the highest death rates. Simultaneous outbreaks of scarlet fever caused by *Streptococcus pyogenes* complicated the picture and added greatly to the mortality. By early 1915, 65 deaths occurred from 529 measles cases for a 12% case fatality rate that was greater than that experienced during the US Civil War.

The USA and UK experiences were reflected on the smaller scale of the AIF, which had 6805 measles cases recorded 1915–1917 although it is likely many cases in recruit camps were under-counted. Measles resulted in 103 deaths for an overall case fatality rate of 1.5% during World War I with only five deaths being from 1918 (See Figure 3).[7] Most deaths (53)

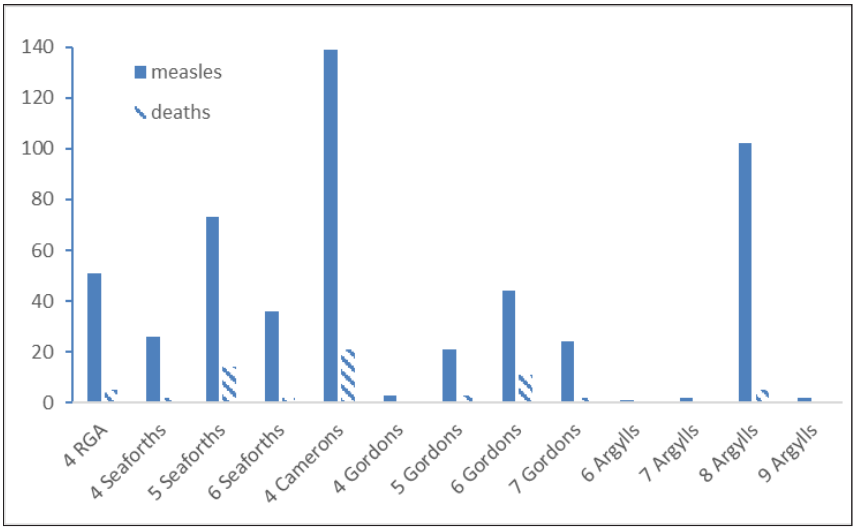


*Figure 2: Measles cases and deaths in UK Highland Division units while training at Bedford, UK from September 1914 to March 1915 showing the wide range of disease and mortality in Scottish soldiers. Five additional units (not shown) had only one measles case each and six additional units had no measles. Infantry battalions labelled as shown with 4 RGA = Royal Garrison Artillery.*

occurred in Australia although measles also killed 14 in Egypt, 16 in UK and 16 in troopships at sea.[8] Considering the largely rural population of Australia in the early 20th century, this was not greatly different from the experience of its USA and UK allies who had larger but more varied populations.

Measles ceased to be a military problem prior to the introduction of measles vaccine in the later part of the 20th century as increased population mixing meant that measles infections occurred in children long before they reached military age. Recruit camp and troopship epidemics occurred in Australia during World War II but there were no recorded deaths due to measles. The safe and highly effective measles vaccine introduced from the 1960s seemed to end the need to consider measles in the military other than to ascertain a soldier's immunisation status on recruitment. Measles, however, was not eliminated globally and retained its pathogenic potential. In 1996, measles immunisation was imperfect in Greece and this produced a large epidemic (1400, 15% attack rate) within the Greek Army.[9] More than 30% (434) required hospitalisation; many had pneumonia most of which were due to bacteria such as *Streptococcus pneumoniae*, *Klebsiella pneumoniae* or *Staphylococcus aureus*. Although there were no deaths, six soldiers were admitted to an intensive care unit and in an earlier generation likely would have died without such support. Both the USA and UK militaries currently report only scattered cases of measles usually restricted to dependant family members whereas mumps is a growing problem reflecting further gaps in public health immunisation programs.

Military missions are evolving such that humanitarian assistance/disaster relief interventions are becoming more common. Measles is a known killer in refugee camps set up in the wake of such disasters, sometimes remarkably so; during the Boer War half of the children put into refugee camps did not survive (nearly 30 000 total deaths, 29% mortality overall) largely due to measles and pneumonia.[10] Measles immunisation campaigns are one of the first public health interventions recommended in most complex public health emergencies to cover populations, which are often already nutritionally compromised with little previous health care access. A high level of clinical acumen is required when looking for an unfamiliar infection in a stressed population that has potentially been exposed to many other infectious agents. Measles should remain on the differential diagnosis of febrile individuals in the tropics even without a distinctive rash as it remains potentially lethal with an outstanding public health response of effective immunisation. Degrading our technological edge against measles by accepting pseudoscientific arguments against modernity must be vigorously avoided. Anti-vaccine campaigners have to be seen in the same category as other belief systems that seek to nullify our known advantages against likely political and disease threats.

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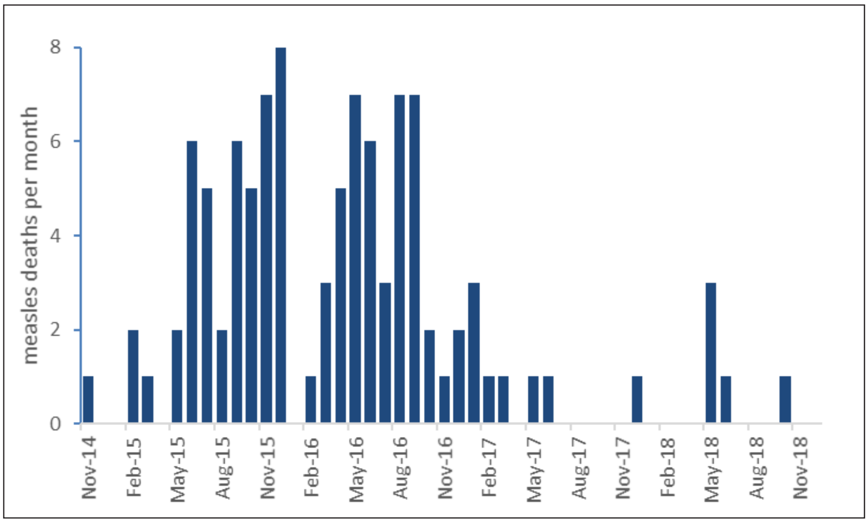


*Figure 3: Measles mortality in soldiers of the Australian Imperial Force 1914–1918 of which 53/103 occurred in Australia before deployment during World War I.*

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*Corresponding author: G. Dennis Shanks*
*dennis.shanks@defence.gov.au*
*Authors: G. Dennis Shanks[1,2]*
*Author Affiliations:*
*1 ADF Malaria and Infectious Disease Institute*
*2 University of Queensland, School of Public Health*

## References

1. Vaughn V. Measles. In: Vaughn V, (ed.) Epidemiology and Public Health: a text and reference book for physicians, medical students and health workers. 1. St Louis, USA: C V Mosby; 1922. p. 144–78.
2. Woodward JJ. Outlines of the chief camp diseases of the United States armies as observed during the present war. Philadelphia, USA: J B Lippincott; 1863.
3. Kilbourne ED. A report of six hundred cases of measles occurring at Columbus Barracks, Ohio. Military Surgeon. 1912;38:294–308.
4. Morens DM, Taubenberger JK. A forgotten epidemic that changed medicine: measles in the US Army, 1917–18. Lancet Infect Dis. 2015;15(7):852–61.
5. Cummings JG. Measles virulence: explanation of variance. Military Surgeon. 1921;47:681–90.
6. Kinnear W. Epidemic of measles in the Highland Division at Bedford, 1914–15. Edinburgh Med J. 1923;30(11):593–9.
7. Butler AG. Statistics of the War in Official History of the Australian Army Medical Services, 1914–1918. Butler AG, editor. Canberra, Australia: Australian War Memorial; 1943.
8. Smallman-Raynor MR, Cliff AD. War epidemics: an historical geography of infectious diseases in military conflict and civil strife, 1850–2000. Oxford, UK: Oxford Univ Press; 2004.
9. Loukides S, Panagou P, Kolokouris D, Kalogeropoulos N. Bacterial pneumonia as a suprainfection in young adults with measles. Eur Respir J. 1999;13(2):356–60.
10. Shanks GD, Hu Z, Waller M, Lee SE, Terfa D, Howard A, et al. Measles epidemics of variable lethality in the early 20th century. Am J Epidemiol. 2014;179(4):413–22.

## Notes

## Notes

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