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- An acute respiratory illness outbreak investigation at an ADF training establishment
- Acute Respiratory Epidemics in Australian Military Forces 1940
- Prehospital Antibiotics in the Australian Defence Force

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2021 AMMA CONFERENCE

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AMMA ADVANCING MILITARY MEDICINE FOR 30 YEARS

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Cover Photo: Courtesy of Department of Defence, CPL Daniel Strutt
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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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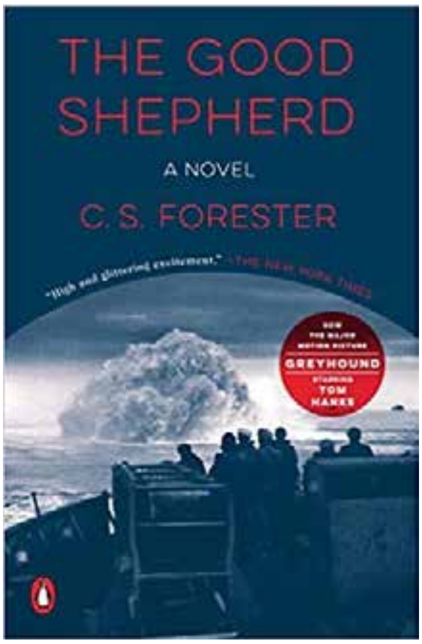
Editorial

Leadership and resilience in a crisis

I recently presented to the Royal United Services Institute in New South Wales on leadership and resilience in a crisis. I particularly noted that while there have been multiple texts published on military leadership, there is limited guidance on leadership in a prolonged crisis and even less guidance on public health leadership in a pandemic.[1] This theme was further explored at the recent Royal Australasian College of Physician's (RACP) Congress in a COVID-19 panel discussion. How do we best prepare our future military health leaders to lead and manage a prolonged crisis, whether that is a public health emergency, a prolonged disaster or a military conflict? Most leadership programs, even military programs, do not focus on the highly disruptive nature of such events, the complexity and ambiguity involved in the decision-making, or the political, regulatory and media overlay. I also recently finished reading *The Good Shepherd* by C. S. Forester (recently released as the film *Greyhound*), which relates to the fictionalised account of the escort of 37 ships to England during the Battle of the Atlantic in 1942.[2] The resilience required by all leaders in such circumstances and how we best prepare them for such roles also require further consideration, particularly as we move into more unsettled times. Some lessons can be learned from the current pandemic, both on crisis leadership and resilience, which we should be factoring into our future training.



Our second issue of 2021 contains a diverse range of articles, focusing on the impacts of infectious disease on military forces. These are also some excellent articles on military health support, communications training and fitness for aircrew training. We continue to attract a good range of articles, including from overseas. We encourage all our readers to consider writing on their areas of military or veterans' health interest. We would particularly welcome papers based on our 2020 conference presentations or those being prepared for our 2021 conference, but welcome any articles across the broader spectrum of military health.

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

1 Robertson A. Leadership and resilience in a crisis: life in the time of coronavirus. United Service. 2021; 72(2):9-13.

2 Forester, C.S. The Good Shepherd. Michael Joseph; London: 1955.

An Acute Respiratory Illness Outbreak Investigation at an Australian Defence Force Training Establishment

O Williams, C Lau, V Ross

Abstract

Background: Influenza outbreaks can spread rapidly in confined settings such as military training establishments, impacting operational capability. There are few published examples of influenza outbreak investigations in contemporary Australian military settings.

Methods: An outbreak investigation was conducted in response to an increase in acute respiratory illness (ARI) cases presenting to an Australian military base health centre in June/July 2019. The investigation included a case test-negative analysis and an estimate of the 2019 influenza vaccine effectiveness in the outbreak population.

Results: A total of 66 cases presented during the outbreak; 27 (40.9%) with confirmed influenza cases, 4 (6.1%) with suspected cases of influenza and 35 (53.0%) cases of non-influenza ARI. Those with confirmed influenza infection were significantly more likely to be from the main training unit on base, have a recorded fever over 38ºC, and have not received the 2019 influenza vaccine. Cases of confirmed influenza also had significantly more time off work than those with non-influenza ARI. Vaccine effectiveness was estimated at 83% (95% CI = 42% to 95%), with an odds ratio of 0.17 (95% CI = 0.052 to 0.554) of confirmed influenza in those with 2019 influenza vaccination record compared to those without.

Conclusion: This outbreak investigation reinforced the Australian Defence Force's policy on influenza vaccination. It highlighted the impact that influenza can have on training and work capability, the need for ongoing outbreak surveillance and investigation, and areas for consideration in improving future outbreak control.

Keywords: influenza, outbreak, Australian Defence Force, case test-negative, vaccine effectiveness

Conflict of interest: Dr Olivia Williams plans to include the outbreak investigation in a thesis submission for Masters of Philosophy in Applied Epidemiology (Australian National University). No further conflict of interest declared by any of the listed authors.

Introduction

Influenza is a common viral respiratory illness transmitted from person to person via aerosol, droplet and contact transmission.[1, 2] Seasonal epidemics occur most years in Australia—generally over winter, between July and September—but severity, rates and timing vary from year to year, depending on changes in the circulating virus and the population's susceptibility to it.[3]

In Australia, influenza outbreaks in closed or confined settings such as aged care facilities,[4] prisons,[5] schools,[6] mass gathering events[7] and cruise ships[8] have been described in the literature. The impact of the 1918 influenza pandemic on Australian Defence Force (ADF) troops is also well documented,[9] and there have been multiple published reports of outbreaks in international military environments.[10-17] However, there is limited literature describing influenza outbreaks in a contemporary Australian military setting.

Trends in seasonal influenza illness in the non-deployed military community have been shown to follow those of the surrounding general population,[18] although it has been suggested that the confined environment of residential military camps results in earlier epidemic peaks than those seen in the general population.[19] When an influenza virus is introduced to the base from an outside source, the close living and working environment, together with training, work or operational conditions, encourage infection transmission.[12, 19]

Most influenza morbidity and mortality occurs in young children, the elderly or those with comorbidities.[1] Published outbreaks in military settings, both in deployed and non-deployed settings, have not reported high rates of complications or hospitalisation.[14, 15, 19, 20] However, severe disease and death from influenza can occur in otherwise young healthy adults,[21] and even moderate illness can contribute significantly to work disruption and absenteeism.[22] In the military setting, this can impact capability and operational readiness, as well as an increased risk of disease spread as the result of a highly mobile workforce.[13]

Annual vaccination is recommended as the most effective measure for reducing influenza illness and complications at a population level,[3] including military populations.[11, 23] Influenza vaccination is currently included in the ADF's routine vaccination schedule and is required for readiness for operations, deployments and major exercises.[24] Availability of the 2019 influenza vaccine for ADF members was announced in late April 2019.

The 2019 seasonal influenza epidemic in Australia saw an earlier rise in influenza cases compared to previous years.[25] In late June 2019, an Australian Defence health centre reported a considerable increase in possible influenza presentations over the previous 24 hours. An outbreak investigation was initiated with the aim of:

- 1. describing the outbreak epidemiology and determine possible aetiology
- 2. implementing control measures to limit transmission and control the outbreak within the base
- 3. reviewing current Defence outbreak management policy.

This paper describes the investigation of an influenza outbreak at an Australian military base during June/July 2019.

Methods

Study setting and population

The Defence base where the outbreak occurred is located within the metropolitan area of a major Australian city and has a focus on training. There are approximately 1200 personnel working on the base, made up of permanent and reserve Defence members and civilian contractors. During the year, Navy, Army and Air Force trainees pass through the base training establishments. The main education unit on the base (referred to in this paper as the training unit) runs courses ranging from three weeks to 18 months duration.

When attending courses, most of the trainees stay in on-base accommodation in single bedrooms with either a separate or shared bathroom. Common areas include the mess for meals, gym, and education and training areas. Military and civilian staff and contractors generally live off base and commute to work each day.

All Defence members have access to free healthcare, including influenza vaccination. The Defence health centre involved in this outbreak investigation (referred to in this paper as the health centre) is located on base and provides primary healthcare to Defence members who work or study within the base. The health centre, staffed by nursing and medical officers, provides outpatient services Monday to Friday and does not have an inpatient capacity.

During this outbreak, unwell members were clinically managed by health centre staff. Those with possible influenza infection were isolated in their rooms under the care of the training unit staff and medics if living in on-base accommodation, or home if living off base. The isolation period was generally five days from onset of symptoms (in line with public health recommendations[2]) or until laboratory results returned a non-influenza swab result and the member was well enough to return to duty. General advice regarding respiratory hygiene, seeking care and isolation if symptomatic, and encouraging influenza vaccination was distributed via email to all staff and students on base. The outbreak was followed until 21 July, six days (two usual incubation periods[2]) following the onset of symptoms of the last confirmed influenza case.

Case definitions

An influenza case was defined as a Defence member who presented to the health centre during the outbreak period with suspected or confirmed influenza, using the Defence policy definitions outlined as follows.

Suspected influenza: A person with onset of respiratory illness from a defined point in time, characterised by fever (temperature >38°C), cough and fatigue.

Confirmed influenza: A person with influenza virus infection confirmed by one or more pathology test.[26]

Those that presented with respiratory symptoms but did not meet the case definition for suspected or confirmed influenza were classified as having a non-influenza acute respiratory infection (ARI).

Data sources

A line list was commenced by health centre staff following the influx of patients presenting with ARI symptoms on 24 June 2019. Details of presenting cases were added daily while pathology results were pending. Clinical information, including presenting symptoms and date of last influenza vaccination, was collected from the Defence e-Health System (DeHS). Influenza vaccination was considered up-to-date if a 2019 influenza vaccine was received more than 14 days prior to the onset of symptoms, allowing adequate time to develop an immune response. Demographic data about the population who had access to the health centre were sourced from DeHS and the training unit command team provided information about trainees attending on-base courses. Pathology specimens collected by clinicians were analysed at privately contracted laboratories.

The rate of influenza cases was compared with historical rates from the health centre using ADF notifiable diseases surveillance data and with state and national rates over the same period using National Notifiable Diseases Surveillance System (NNDSS) data.

Data analysis

Descriptive analyses were performed on the whole outbreak cohort and each subgroup according to case definitions. Variables included age, sex, student or staff status, unit, living location, date of onset of illness, presentation date to the health centre, symptoms on presentation and influenza vaccination status.

A test-negative design compared confirmed influenza cases with non-influenza ARI controls. Cases that met the definition for suspected influenza were excluded from analysis to reduce misclassification error. Chi-square analysis was used to assess differences between the two groups for categorical variables, and Mann-Whitney U tests were used to compare non-parametric continuous variables.

Crude odds ratios were calculated using binary logistic regression to assess for predictors of confirmed influenza illness. Statistically significant variables were included in multivariate analysis with age and sex to calculate the adjusted odds ratio comparing the odds of 2019 influenza vaccination in confirmed influenza and non-influenza ARI groups. Vaccine effectiveness was calculated using the equation (1 – odds ratio) x 100%.[27]

Significance was determined at P-value < 0.05. Data analyses were performed using SPSS Statistics 24 (IBM SPSS Statistics for Windows, Version 24.0, NY:IBM Corp).

Ethics

This outbreak investigation was conducted under the authority of Defence Regulation 2016 and Defence Instruction – Administrative Policy and in accordance with the Defence Health Manual.

Results

There were 809 Defence members recorded as attached to the health centre in June 2019, with 43.5% documented as having received a 2019 influenza vaccination. An estimated 400 trainees passed through the base during the outbreak period; however, it is unknown how many of these trainees were vaccinated. Demographics of the population registered with the health centre as of October 2019 (n = 769) are outlined in Table 1 and are assumed to be similar to those of the health centre population at the time of the outbreak.

Descriptive analysis

All ARI cases

The line list consisted of 66 ADF members who presented with ARI during the outbreak period, with a median age of 25 years (range 18 to 52 years) and 81.8% (n = 54) males. Of those included in the line list, 40 (60.6%) were living in on-base accommodation, 42 (63.6%) were trainees, 55 (83.3%) were from the training unit, and 29 (43.9%) had an up-to-date influenza vaccination recorded in DeHS.

The most common symptoms on presentation were nasal congestion (80.3%), cough (75.8%) and sore throat (66.7%). A temperature above 38°C was recorded in 13 cases (19.7%), while 32 (48.5%) members reported symptoms of fever. There were no hospitalisations or severe complications, and none of those who presented with ARI had comorbidities or conditions that increased their risk of complications from influenza. ARIs identified during the outbreak resulted in 213 person-days of sick leave from work with a median of 3 days per person. Only one case was prescribed antivirals based on the clinical decision of the treating medical officer.

Nasopharyngeal swabs were collected from 65

Table 1. Demographics and presenting symptoms according to case definition

	Confirmed influenza	Non-influenza ARI	*P*-value*	Suspected influenza	Health centre population (Oct 2019)
Total number n	27	35		4	769
Age range (years) n (%)					
<= 24	11 (40.7)	16 (45.7)		1 (25.0)	178 (23.1)
25–29	9 (33.3)	7 (20.0)		1 (25.0)	136 (17.7)
30–34	1 (3.7)	5 (14.3)		1 (25.0)	132 (17.2)
35–39	3 (11.1)	2 (5.7)		0	101 (13.1)
40–44	2 (7.4)	4 (11.4)		1 (25.0)	84 (10.9)
45+	1 (3.7)	1 (2.9)		0	138 (17.9)
Age (years)					
median (range)	26.0 (19–49)	25.0 (18–52)	0.96	28.5 (18–43)	
Sex n (%)					
Male	22 (81.5)	29 (82.9)	0.89	3 (75.0)	652 (84.8)
Female	5 (18.5)	6 (17.1)		1 (25.0)	117 (15.2)
Unit n (%)					
Training unit n	26 (96.3)	25 (71.4)	0.01	4 (100)	380 (49.4)
Other units	1 (3.7)	10 (28.6)			
Personnel					
Staff	6 (22.2)	3 (8.6)	0.24	2 (50.0)	
Trainees	18 (66.7)	22 (62.9)		2 (50.0)	
Unknown	3 (11.1)	10 (28.6)			
Accommodation					
Live on base	17 (63.0)	20 (57.1)	0.64	3 (75.0)	
Live off base	10 (37.0)	15 (42.9)		1 (25.0)	
2019 Influenza Vaccination† n (%)	7 (25.9)	20 (57.1)	0.002	2 (50.0)	
Clinical symptoms reported at presentation n (%)					
Subjective fever	15 (55.6)	17 (48.6)	0.59	0 (0)	
Measured fever ‡	9 (33.3)	0 (0)	<0.001	4 (100)	
Cough	21 (77.8)	27 (77.1)	0.95	2 (50.0)	
Sore throat	17 (63.0)	25 (71.4)	0.48	2 (50.0)	
Nasal congestion	23 (85.2)	28 (80.0)	0.60	2 (50.0)	
Headache	15 (55.6)	17 (48.6)	0.59	3 (75.0)	
Myalgia/arthralgia	15 (55.6)	15 (42.9)	0.30	3 (75.0)	
Malaise	9 (33.3)	9 (25.7)	0.51	1 (25.0)	
Days between onset of symptoms and swab					
Median (IQR)§	2.0 (2.0-3.0)	2.0 (1.0-3.0)	0.78	0.5 (0.0–1.8)	
Days not fit for duty					
Total person-days	111	87		14	
Median (IQR)	5.0 (3.0–5.0)	2.0 (1.0–4.0)	0.001	2.5 (0.8–5.3)	

* *Comparing confirmed influenza and non-influenza ARI*
† *2019 Influenza vaccination given 14 days or more prior to onset of symptoms*
‡ *measured temperature >38°C recorded in clinical consultation notes*
IQR = Inter quartile range

(98.5%) people included on the line list and tested for respiratory viruses by polymerase chain reaction (PCR). The median time between the onset of symptoms and the collection of a respiratory swab for PCR was two days. No other pathology tests for influenza were ordered by clinical staff during this outbreak.

Of those swabbed, 27 (41.5%) were positive for influenza (24 influenza A, three influenza B), 18 (27.7%) were positive for a non-influenza respiratory virus and 20 (30.8%) had negative respiratory PCR swabs. Of those with a negative PCR swab, three met the case definition for suspected influenza infection. One person did not consent to being swabbed but met the case definition for suspected influenza. There were no co-infections detected on respiratory PCR testing and subtype of influenza A infections was not provided. Overall, 27 (40.9%) cases met the case definition for confirmed influenza, 4 (6.1%) met the case definition for suspected influenza, and 35 (53.0%) cases were defined as non-influenza ARI (Figure 1).

The outbreak spanned four weeks, with the onset of ARI symptoms reported from 18 June to 17 July 2019 and presentations to the health centre from 20 June to 18 July 2019. Over half of all ARI cases included in the line list presented to the health centre (54.5%) in the first two weeks of the outbreak (Figure 2).

Confirmed influenza cases

The median age of confirmed influenza cases was 26 years (19–49 years), with 81.5% male, 96.3% from the training unit and 18.5% having received the 2019 influenza vaccination (Table 1). The most common symptoms on presentation in confirmed cases of influenza were measured or subjective fever (88.9%), nasal congestion (85.2%), cough (77.8%) and sore throat (63.0%). Confirmed influenza cases accounted for 111 person-days of sick leave, with a median of 5 days per person. Eighteen (66.7%) confirmed influenza cases presented in the first two weeks of the outbreak (Figure 2).

Confirmation of outbreak

Surveillance data showed an increase in reported cases of confirmed influenza for the health centre compared to the preceding months and the June/ July period in the previous two years (Figure 3). Rates of confirmed influenza from the health centre were calculated using the health centre population in June (n = 809) plus the estimated number of

Figure 1. Cases presenting with acute respiratory illness (ARI) to the health centre and included in the outbreak investigation

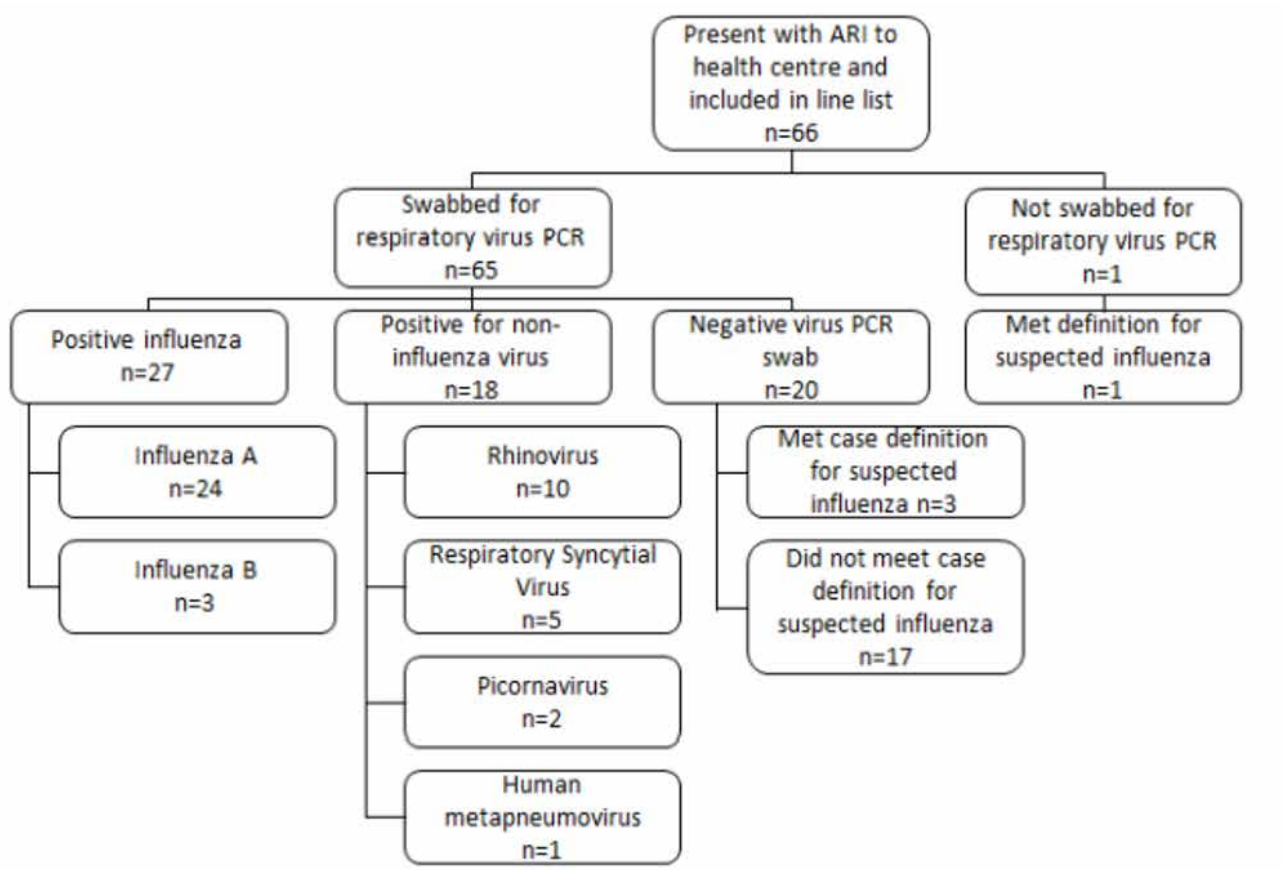


Figure 2. Number of cases according to date of presentation to the health centre and case definition

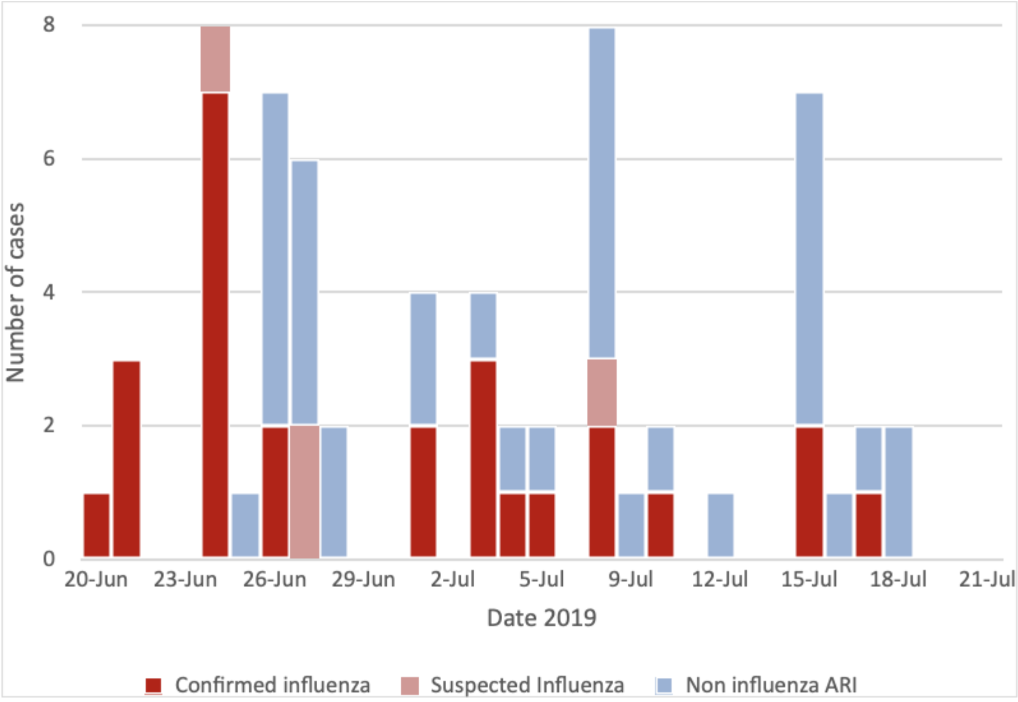
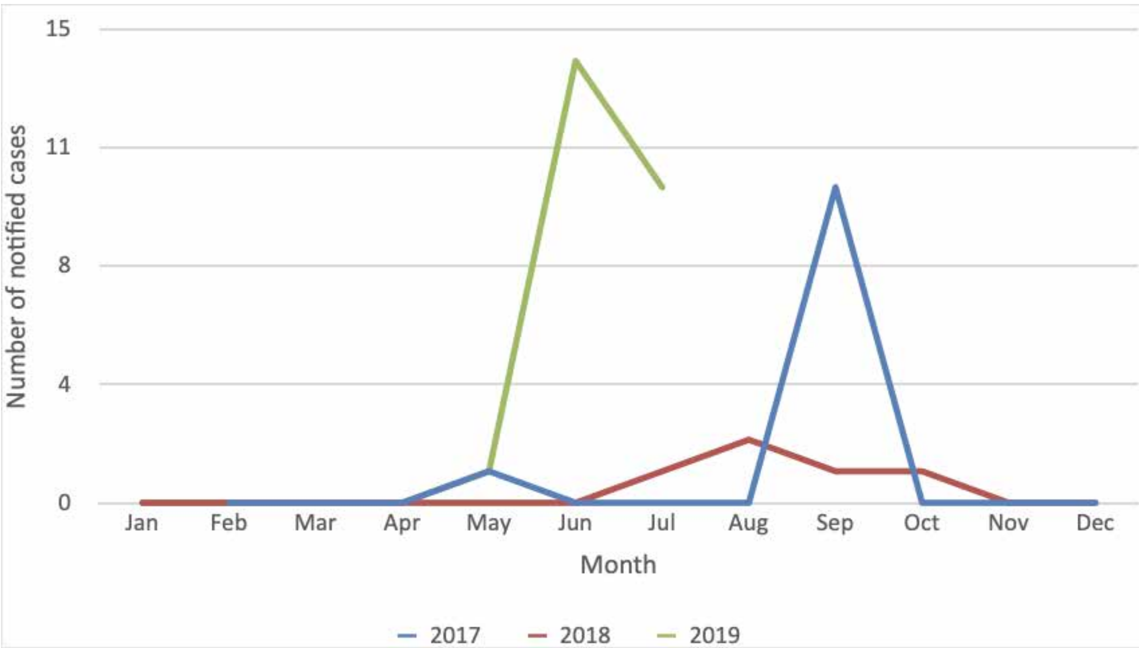


Figure 3. Notified cases of confirmed influenza from the health centre

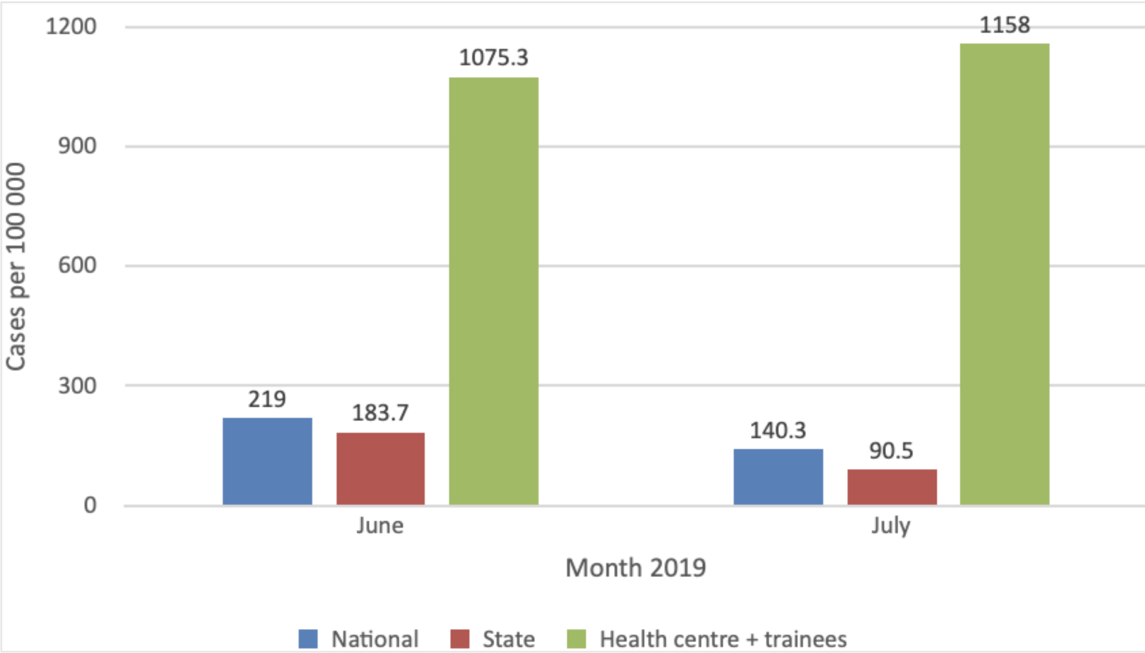


trainees on base during the outbreak period (n = 400). Comparison of confirmed influenza rates with state and national laboratory-confirmed influenza notification rates showed much higher attack rates at the health centre (Figure 4).

Comparative analysis

There was no statistically significant difference between influenza and non-influenza ARI groups regarding age, sex, proportion living in on-base accommodation, number of trainees and time between onset of symptoms and respiratory swab

Figure 4. Reported laboratory-confirmed influenza cases per 100 000 for Australia, state and health centre plus trainee populations



National and State reported laboratory-confirmed cases[30]

collection. Those with confirmed influenza were significantly more likely to be from the training unit (96.3%) and to have a recorded temperature above 38ºC (33.3%), compared to those who presented with non-influenza ARI (71.4%, 0% respectively), and less likely to have documentation of having received a 2019 influenza vaccination more than 14 days prior to the onset of symptoms (18.5% vs 57.1%). Those with an influenza diagnosis had significantly more days unfit for work per person (median 5 days) compared to a non-influenza ARI diagnosis (median 2 days).

Case test-negative analysis

Case test-negative analysis was used to compare the 27 confirmed influenza cases with the 35 influenza test-negative cases. Univariate logistic regression analysis showed that only influenza vaccination status and being from the training unit were significantly associated with confirmed influenza illness. Adjusting for age, sex and unit had little effect on the odds of confirmed influenza in vaccinated compared to unvaccinated members (Table 2). Among ARI cases included in this outbreak investigation, adjusted odds of confirmed influenza in those from the training unit was 11.7 times the odds of influenza in those from other units. Adjusted odds of confirmed influenza in those who had received a 2019 influenza vaccination was 0.17 times the odds of influenza in those who were not vaccinated. Vaccine effectiveness was 83% (95% CI = 42% to 95%) among ARI cases included in this outbreak investigation.

Discussion

This paper documents an investigation into an increase of ARI presentations at a Defence health facility. Pathology testing confirmed an influenza outbreak, primarily affecting young trainees from the main training unit on base. Age and sex distributions of the outbreak cohort are considered to reflect the trainee population on base at the time of the outbreak. Notably, this investigation demonstrated that influenza diagnosis was significantly less likely in those who had a documented 2019 influenza vaccination. It also showed the impact of influenza illness on workforce capability with significantly more days off work due to influenza than non-influenza ARI.

This outbreak investigation demonstrated high vaccine effectiveness when compared with other studies. An Australian general population study calculated an overall 2017 influenza vaccine effectiveness of 39% (95% CI = 24% to 51%) for the 15 to 64-year-old age group.[28] Military studies of predominantly young male populations found overall 2009 influenza vaccine effectiveness rates

Table 2. Odds ratio of confirmed influenza illness

	OR	95% CI	P-value	aOR	95% CI	*P*-value
2019 Influenza vaccination						
Yes	0.17	0.05–0.55	0.003	0.17	0.05–0.58	0.005
No	Ref			Ref		
From communications training unit						
Yes	10.400	1.24–87.31	0.03	11.669	1.23–111.04	0.03
No	Ref			Ref		
Age	1.001	0.94-1.06	0.98	0.977	0.91-1.05	0.55
Sex						
Male	0.910	0.25–3.37	0.89	0.78	0.17–3.63	0.75
Female	Ref			Ref		

OR = Odds ratio
aOR = Adjusted odds ratio
95%CI = 95% confidence interval
Ref = reference group

of 46.8% (95% CI = -9.4 to 74.1)[16] and 45% (95% CI = 33 to 55%).[23] Influenza vaccine effectiveness in the outbreak described in this paper was calculated at 83%; however, the comparatively small study population resulted in low precision with a wide 95% CI (42% to 95%) that overlapped with previous studies' findings.

Vaccine effectiveness from this investigation was based on findings from a single outbreak, constrained in time and location, and without consideration of subtype of influenza A positive specimens. Previous Australian studies have shown that vaccine effectiveness can vary considerably depending on influenza strain and vaccine matching.[27, 28] Greater vaccine effectiveness would be expected in outbreaks with influenza virus diversity limited to strains with high vaccine matching. Vaccine effectiveness calculated from this single investigation may not reflect overall vaccine effectiveness to multiple influenza strains and subtypes seen in varied locations and populations over a season.

Strengths of this study include limited confounding variables, presumed high presentation rates to the health centre and high swab rates. Commonly acknowledged confounders in the analysis of vaccine effectiveness include extremes of age, comorbidities and time of year of presentation.[27, 28] The young and predominantly healthy population and short study period in this investigation helped minimise these confounders.

Presentation rates of unwell Defence members could be presumed to be high because of easy access to health care, and organisational demands and expectations. However, a perceived culture of shunning weakness, or pressure from training-related timelines that can impact career progression, might also influence health-seeking behaviours in Defence trainees. Other authors have expressed similar concerns about health-seeking behaviours within a deployed military environment.[13]

High swab rates for investigation of ARI in this outbreak helped reduce misclassification error. While specificity and sensitivity of respiratory PCR are generally high; sensitivity can be affected by poor specimen collection and handling and prolonged time from onset of illness to specimen collection.[1] In this investigation, patients tended to present early, with respiratory swabs generally done on initial presentation. There was no significant difference in the number of days from onset of symptoms to respiratory swab between confirmed influenza and non-influenza ARI groups. The high proportion of positive viral PCR tests during this outbreak supports adequate swab quality collected by the health centre.

This study's weakness was the reliance on clinician discretion for patient investigation and inclusion on the line list rather than according to predefined clinical case definitions. Initially, when clinical staff focused on operational priorities, cases may not have been included in the line list. As the outbreak progressed, the number of presentations and respiratory swabs conducted likely increased as a result of heightened awareness among Defence members and health centre staff. Data on presenting symptoms were collected from clinical notes rather than a standard questionnaire, which may have affected questioning and reporting consistency. Data on vaccination status were obtained from e-health records and, while it eliminates recall bias, relies on good record keeping.

In this outbreak, patients presenting with fever were significantly more likely to be diagnosed with confirmed influenza than a non-influenza ARI. This supports the use of fever in the Defence policy case definition for suspected influenza. Several publications have supported the finding of a temperature above 38°C as a predictor of influenza.[1, 10] Other studies suggest including reported or subjective fever in the influenza case definition to improve sensitivity;[13, 15] however, this is likely to reduce specificity. In this study, there was no significant difference in the proportion reporting subjective fever between those with confirmed influenza and those with non-influenza ARI.

While multiple non-pharmacological public health measures were used to help control the outbreak described in this paper, antiviral prescription was uncommon. Australian public health recommendations focus on antiviral use to treat and prevent transmission of influenza infection in those that are at high risk of complications.[2] However, papers have discussed the use of antiviral medication to reduce transmission from infected individuals[13] or for post-exposure prophylaxis[29] to control influenza outbreaks in confined military settings. Appropriate antiviral prescription can also shorten the infective period, reducing isolation time[2] and duration of illness, and may have a role in Defence settings where organisational or operational requirements demand minimal time away from duty.

The primary aim of this investigation was to guide outbreak management. Real-time analysis of findings allowed identification of the cause and the groups most affected and provided the opportunity to influence outbreak control measures, including quarantine of heavily affected training groups, targeted hygiene advice and base-wide promotion of influenza vaccination.

The investigation also provided an opportunity to review the current Defence outbreak management policy. Recommendations resulting from this investigation included ongoing surveillance of influenza cases; outbreaks and vaccination rates to better understand disease burden on Defence; training and support of clinical staff in outbreak management in high-risk Defence settings; encouraging the use the of case definitions to identify cases once an outbreak is established rather than ongoing testing; discussions about the role of antivirals in high-risk Defence settings; and educating commanders on the impact of influenza on, and the role of vaccination in protecting capability. While acknowledging the limitations of the findings from a single outbreak, this investigation supports routine annual influenza vaccination to protect the ADF population from influenza illness, particularly those in confined training and living environments. Ongoing influenza surveillance and outbreak investigation within Defence will enable a complete analysis of influenza infection and vaccination effectiveness across diverse Defence populations in varied locations and over different seasons. Future research should further examine the role of antivirals in helping control influenza outbreaks in these high-risk ADF settings to establish guidelines for antiviral use for transmission reduction and prophylaxis.

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Colonel Arthur Graham Butler's 'Allegiances': Today's 'Military Health Service Missions'

N Westphalen

Introduction

This article follows previous papers by the author regarding occupational and environmental medicine in the ADF.[1,2,3,4,5,6,7,8,9,10]

These articles, as well as a 2019 Productivity Commission inquiry,[11] explain why 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.[12]

Doing so would require reassessing the fundamental inputs to capability (FIC)[13] for both Joint Health Command (JHC) 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 civilian specialist practitioners within the Australasian Faculty of Occupational and Environmental Medicine (AFOEM), suggest that a mature holistic and sustainable model would take 10–15 years' sustained effort.

This article expands on these papers, regarding what Colonel Arthur Graham Butler referred to in his official WWI medical history as the 'allegiances' of military health services, and how, in today's parlance, these can and should be considered their elemental and enduring 'missions'.[14]

Biography[15]

Arthur Graham Butler was born at Kilcoy, QLD, on 25 May 1872, the son of station manager William Butler and his wife June (née Graham). He studied at Cambridge in the UK for a Master of Arts (1894), followed by medicine and surgery (1897, 1899) before entering general practice at Kilcoy and then Gladstone. He left Gladstone in 1907 for 12 months' postgraduate study at the University of Sydney and began a specialist obstetric and gynaecology practice in Brisbane. He also became the honorary secretary of the Queensland branch of the British Medical Association or BMA (precursor to the Australian Medical Association) from 1912 to 1914.

Having entered the Australian Army Medical Corps (AAMC) in 1912 as the Moreton Regiment medical officer,[16] Butler joined the Australian Imperial Force (AIF) as a captain on 20 August 1914. He was appointed regimental medical officer to the 9th Battalion, whose officers and men quickly nicknamed him 'Gertie'. Besides referring to his older age, the name suggests they believed his medical preparations excessive, whereas his biographer (probably quite rightly) called them 'meticulous'.

Butler's actions during the Gallipoli campaign belied their moniker. He was in one of the first boats ashore at Anzac Cove on 25 April 1915; was evacuated sick in July; returned a month later and remained until the withdrawal in December. Having been promoted to major, Butler was the only Australian medical officer to win the Distinguished Service Order during the Gallipoli campaign for conspicuous gallantry and devotion to duty in attending casualties under heavy fire.[17]

Captain Arthur Graham Butler, Gallipoli, July 1915[18]

In February 1916, Butler was appointed the I Anzac Corps Deputy Assistant Director of Medical Services (DADMS), a role he continued after arriving in France in April. It entailed supporting the corps Assistant Director (Colonel Courtenay Clarke Manifold, Indian Medical Service), whose role was ill-defined but generally entailed coordinating his divisional Assistant Director subordinates' activities. Further to his writing talent inherent to having a MA, it should be noted that this also enabled Butler to gain useful staff skills from an administratively experienced medical officer, which were otherwise generally lacking within the AAMC at the time.

Butler was promoted to lieutenant colonel in November 1916, and given command of the 3rd Field Ambulance in February 1917. It was employed as the 1st Division's main dressing station until September when it took over the Menin Road advanced dressing station. Having been twice mentioned in dispatches, Butler was sent to the AIF headquarters in London in May 1918 to help collate its medical records. He then commanded the 3rd Australian General Hospital at Abbeville as a colonel, from July 1918 until it closed in June 1919. After another six months at the AIF war records section, Butler was demobilised in February 1920, whereupon he resumed his Brisbane private practice and became the State BMA president.

Lieutenant Colonel Arthur Graham Butler, London, 1918[19]

3rd Australian General Hospital, Abbeville, 23 June 1918[20]

War Diaries Subsection, War Records Section, AIF Headquarters, London, June 1919[21]

In 1923, Butler was persuaded to write the official history of the wartime AAMC. This task occupied the next 20 years of his life, for which he gave up his practice and moved to Canberra. Having written all except those parts of the first on the German New Guinea campaign, and the RAN section of the third, his three-volume history was published in 1930, 1940 and 1943. In seeking to isolate and analyse important problems as a guide to future medical health policy and management, Butler's history has been considered one of the English-speaking nations most distinguished war histories.[22]

Official History of the Australian Army Medical Services in 1914-19 (author)

Dr Arthur Graham Butler and Dr Allan Seymour Walker (official WWII medical historian), Australian War Memorial, 19 June 1945[23]

Butler died in Canberra on 27 February 1949, and was buried in St John's Baptist Church in Reid, Canberra. He was survived by his wife Lillian and daughter Joan (wife of Air Vice Marshal Sir Valston 'Val' Hancock).[24] A colleague said of Butler, 'he was everything that gentle upbringing, the highest education, Christian philosophy, unbounded comradeliness, fearless integrity, the zeal of an idealist, and boyish humour and enjoyment of life could make a man'.[25]

Butler's grave, St John's Baptist Church, Reid, Canberra (author)

Butler's 'allegiances' and their relevance to military health services

For this paper, Butler's description of what he termed the 'allegiances' of military health services are worth quoting in full (underlining added):

> '*As we follow the course of the casualties, sick and wounded, from the front through the various levels of evacuation to their distribution and final disposal, and examine the system, whereby, in the last years of the war, temporary "wastage" from the front and loss of strength through present "unfitness for service" were reduced to their minimum and the morale and health of the force maintained, we find three prime purposes intermingling in the manifold activities of the medical service, each related to a specific responsibility and mandate. To the military command, it owed service to promote and conserve man-power for the purpose of war. To the nation at large, it was responsible for promoting by intelligent anticipation the efforts of the civil institution whose*

> *duty it should be to prepare for useful return to civil life the soldiers unfitted for further military service. By Humanity, as represented by the nations who had subscribed to the International Convention of Geneva and the Hague, it was charged with minimised so far as possible the individual sufferings of the combatants of both sides. These three strands of purpose, inextricably interwoven as they were, in a self-contained and consistent scheme of medical service nevertheless furnished each as an end in itself—all three entering at every stage into the medical problem, and now one, now another, providing its dominating motive.*[26]

This paper is premised on the following.

- Butler's wartime experiences, as a decorated battalion medical officer, field ambulance and general hospital commander, and staff medical officer, ensure his credibility as a military clinician and administrator, attributes he shared with many of his contemporaries.
- However, unlike his contemporaries, Butler spent much of his life writing a well-regarded history that comprehensively analysed the AAMC's activities during WWI, and the enduring elemental lessons to be learned therefrom.
- The aforementioned quote represents an encapsulation of these lessons, which Butler referred to as the three 'allegiances' of military health services.
- Despite Butler's intentions, the lessons he identified have since been lost, not least by subsequent Australian official military medical histories.[27,28,29]
- 80 years later, Butler's 'allegiances' would now be referred to as military health service 'missions'.

The rest of this paper analyses Butler's 'allegiances' and the extent to which they continue to represent the elemental and enduring missions of today's military health services in general and the ADF health services in particular.

Butler's humanity 'allegiance': the treatment services mission

Butler notes that military health services owe an 'allegiance' to humanity, to minimise as much as possible the suffering endured by military personnel. Notwithstanding the advances in clinical care since, this mission in itself is no different to civilian health services, especially given the overlap with some casualty evacuation and most military humanitarian aid/disaster relief (HA/DR) and operations.[30]

However, a primary distinction is that civilian health services have no remit regarding the military operational capability or civilian transition missions. Furthermore, previous articles describe how military health services are differentiated from their civilian counterparts, in that the population they provide care for is (by definition) exclusively working age, while most of their clinical conditions (in particular musculoskeletal and mental health disorders) are either caused by their work, or affect their ability to perform their work.[31,32]

These articles also note that even in peacetime, ADF members can often be exposed to a variety of physical, chemical, biological, ergonomic and psychosocial workplace hazards. To these can be added combat-related workplace hazards deliberately intended to cause harm, in the form of weapons such as small arms, grenades, mortar and artillery rounds, sea-, land- and air-launched missiles, sea and land mines, and torpedoes, which can cause death or injury secondary to penetrating wounds, blunt trauma, blast injuries and/or burns. Nuclear and other radiological weapons pose additional physical hazards, as do biological hazards from weaponised bacteria, viruses and toxins, and chemical hazards from weaponised blistering, choking and nerve agents.[33,34]

These considerations explain why even in peacetime, Butler's wartime humanity 'allegiance' would now be referred to as the military health services' 'treatment mission', while the work-relatedness of the illnesses and injuries requiring treatment justify why these services ought to be based on a broader systems-based occupational health strategic model.

Butler's military command 'allegiance': the operational capability mission

Butler notes that military health services also owe an 'allegiance' to commanders to promote and conserve personnel for the purpose of war. To this end, he also wrote (underlining added):

> *'Most writers who deal with the part of medicine in the war tacitly accept as a postulate—as it is also a matter of general belief—that the one essential feature of the work of the medical service in the late war was to bring about a greatly diminished incidence of disease. As will be shown, close study of facts and figures makes clear that this attitude must be modified.*

> *The many problems associated with civilian participation in military activities on the one hand, and with the reinstatement as civilians of the wastage from warfare on the others, will be found to open up in the chapters of this section. They do so along two lines—positive, in the vast domain of 'reparative' treatment, surgical and medical; and negative, in the only less arduous and exacting work of the military boards and the military machinery for implementing the system of "category".*[35]

It should be noted Butler wrote extensively elsewhere regarding the role of sanitation, vector control and related health services, and the role of military dental services in enabling military operations by reducing preventable disease and non-battle injuries.[36,37]

Butler makes a key point noting that the scope of personnel conservation not only entails returning injured and sick personnel to normal duty where possible. He also refers to the need for a robust medical categorisation process that keeps commanders informed of their personnel's health status to maximise their utilisation in achieving their mission(s).[38,39] Besides articulating the role of the current ADF Medical Employment Classification System and its antecedents as personnel rather than patient management tools, Butler presciently anticipated the RACP's Position Statement *Health Benefits of Good Work*, and its applicability in the ADF health setting.[40]

However, this paper contends that the operational capability mission is far broader than simply providing the treatment and preventive medicine services required to conserve personnel. It must be remembered that Butler's experiences reflected an especially grim form of industrial-scale attrition warfare, for which preserving personnel strength as an end unto itself proved essential to victory. The same could also be said of the WWI campaigns in Mesopotamia (modern Iraq) and East Africa, and the WWII Burma and Southwest Pacific campaigns, where the key component to operational success pertained less to managing combat casualties than controlling overwhelming rates of preventable disease.[41,42,43,44,45] This and previous papers explain why the scope of the ADF's preventive medicine services should also include non-combat workplace injuries.

Rather, another key yet under-recognised component of the operational capability mission is to facilitate additional flexibility to commanders as to how they can achieve their operational tasks than they would have otherwise. For example, the scope of medical CBRN defence is not limited to simply preventing and treating such casualties but also enables operations to continue despite ongoing CBRN threats.[46] For a somewhat less fraught peacetime example, although the health services for Operation BEL ISI II in Bougainville from 1997 to 2003 were perhaps clinically under-employed, their contribution to operational capability just by 'being there' should not be underestimated. Besides enhancing operational flexibility in achieving the commander's peace monitoring mission, their presence also helped maintain personnel morale at the tactical level and the broader community, media and hence government support for BEL ISI II at the strategic level.[47] Finally (but by no means less importantly), military health services also render feasible physiologically demanding operations, such as those pertaining to the ADF's aviation, diving and submarine capabilities.[48]

Even so, despite undertaking clinical work at Duntroon from 1927 to 1930, Butler seems not to have recognised the extent to which his military command 'allegiance' extends beyond combat operations, most likely because the Australian Army at that time—including its medical services—was almost exclusively based on a part-time militia force that was not required (and in fact legally unable) to deploy overseas.[49] This should be compared with health support for Navy's peacetime overseas operations at that time, to locations where shore-based health services were simply not available within an operationally or clinically appropriate timeframe.[50]

These considerations explain the contention per previous papers that, even in peacetime, *all* military health services at *all* levels have a role in facilitating *every* commanders' mission (irrespective of whether it entails being deployed). Hence, the military health services' 'enabling operational capability mission' likewise necessitates a systems-based occupational health strategic model. However, these papers have also referred to the outgoing SGADF's comments per the 2019 Graham Shirtley Oration, indicating ADF commanders remain dissatisfied with the health support they receive.[51] This paper contends that a primary reason pertains to the lack of consideration given by JHC and its DHS predecessor to this mission, especially regarding operational activities that do not entail deployment. This, in turn, reflects longstanding misperceptions within JHC and elsewhere within Defence regarding the *true* scope of this mission and (in particular) how much it costs, without also recognising the cost to operational capability, of *not* performing them. Furthermore, the fact that many ADF members conduct operational roles *without* necessarily deploying, also explains why *their* enabling health staff should likewise be under military discipline.[52,53,54,55,56]

Butler's civilian community 'allegiance': the civilian transition mission

Finally, Butler notes that military health services owe an 'allegiance' to the nation at large to facilitate the civil institutions responsible for returning military personnel deemed unfit for further service to the civilian community. For more than a century, the primary institution he referred to has been the Department of Veteran Affairs (DVA), and its antecedent organisations.[57] However, previous articles and the aforementioned Productivity Commission inquiry have highlighted the need for substantial reform, particularly regarding rehabilitation and compensation.[58,59,60,61]

It should be noted that Butler began writing his history at a time when the 'Repat' provided services for hundreds of thousands of ex-AIF members with war-related illnesses and injuries and that many 'Repat' service providers themselves had wartime experience. Among other factors, this meant that the latter could, for example, 'fill in the gaps' when reviewing each claimant's often scant wartime clinical and other documentation, perhaps decades later. Post-WWII 'Repat' assessors also possessed this capability in the 1980s, many of whose wartime service was comparable to 'Repat' claimants.

However, the tribulations endured by Vietnam War veterans indicate the extent to which their assessor's wartime experience had to be relevant to that of their claimants. Furthermore, the issues faced by Gulf War and subsequent veterans demonstrate how DVA assessors became and remain unable to 'read between the lines' regarding each claimant's clinical and other documentation where it exists. The claims process is further hampered by the exclusion of occupational physicians, despite their specific training in assessing clients, providing impartial advice regarding their eligibility and treatment, and facilitating their return to work.[62,63]

This limitation highlights why it is essential that *all* ADF personnel—*not* just the medically separated ill and injured members referred to by Butler—should be managed as potential DVA clients from when they *first* join. However, previous articles explain why the current organisational split between the clinical services provided by JHC, and the reporting of those illnesses and injuries deemed work-related to the Defence Work Health and Safety Branch, is actively inimical to achieving this mission.[64,65] This situation is not improved by largely bureaucratic rehabilitation processes that lack specialist rehabilitation and occupational physician clinical input and have no outcome measures do not include their success in actually returning ADF members to normal duties.[66] These organisational deficiencies further support the contention that the military health services 'civilian transition mission' requires a systems-based occupational health strategic model.

Butler's 'quo vadimus?' ('where are we going?'): a false choice

Having reiterated his 'allegiances' at the beginning of his third volume epilogue, Butler concludes:

> *'The Army Medical Service seems to be at the parting of the ways. One road might lead it to complete devotion to purely military ends—the winning of war at any price. If that happened, the task of keeping alive the principle of humanity and of safeguarding the social interests of the State and the individual would be left more and more to the voluntary and civil organisations* [as referred to elsewhere in his epilogue, which would now be referred to as non-governmental organisations or NGOs]. *On the other hand, in spite of the military commitments to ruthless warfare, it may retain its triple responsibility. Which way it goes must depend on the extent to which medicine, regarded as a social group, tends to give its souls as well its body to the ideal of "total ruthlessness", or (on the other hand), to co-operate with social influences in maintaining the humane ideal… towards which* homo sapiens *has slowly, painfully but bravely climbed from the primeval jungle.'*[67]

Unlike his 'allegiances', Butler's perception that military health services face a binary choice between military versus humanitarian needs has since attracted attention.[68,69] Once again, it must be recognised that his rather despairing verdict was written during another worldwide cataclysm, which frequently saw the perversion of medical science for the perpetration of evil, over and beyond the previous conflict. Furthermore, it should also be acknowledged that such threats to Butler's treatment 'allegiance' remain extant.[70,71] However, the recent inquiry into alleged atrocities by Special Air Service Regiment personnel demonstrates the need for military health services to be actively engaged with operational commanders to prevent, or at least belatedly publicise, such incidents.[72] To these can be added their ability to support HA/DR operations in higher-threat environments where NGOs cannot work[73] and support good work for peacetime operations.[74]

In short, Butler's 'quo vadimus' question represents a false choice: rather than isolating medical services from potential war criminals, the most challenging aspect of military medicine pertains to balancing his 'treatment' allegiance against the other two missions—not only for humanitarian purposes as ends unto themselves, but also to facilitate operational capability by assisting commanders to prevent such crimes (and if necessary, bearing witness should this fail), as well as reducing long-term mental health issues among their personnel by ameliorating the more egregiously preventable horrors of war.

The interaction between these missions

Butler notes that the 'allegiances' he refers to are not discretely separate, but intrinsically linked depending on circumstances. By way of an elemental demonstration, let us consider a typical ADF primary health care presentation. Besides the normal clinical process of taking a history, examining the patient, performing investigations, formulating a diagnosis and prescribing treatment (i.e. the 'treatment mission'), Defence clinicians also need to consider the following for each ADF patient.

- The 'operational capability mission'. This entails considering whether or not the diagnosis and/or treatment limits or prevents the patient's ability to perform their normal duties, or vice versa, that is, whether their normal duties will affect their diagnosis or treatment. If they do, consideration needs to be given to how either or both affects their commander's mission. For example, losing the lead Air Battle Manager (ABM) in a Wedgetail crew to illness will require substantial changes in personnel management if he or she is unfit to fly, compared to another ABM with the same diagnosis who is not assigned to flying duties. Furthermore, it will also change their clinical management and prioritisation if the patient in question is the only available ABM for a particular mission.
- The 'civilian transition mission'. This entails careful documentation as to how and why the patient's illness or injury occurred. Although assessing work-relatedness can be straightforward, this may not always be the case, especially for conditions such as mental health disorders, whose clinical effects resulting from work-related exposures and vice versa may not be readily apparent. Besides documenting work-related illnesses or injuries for future treatment liability and compensation purposes, this component of the care provided also needs to be fed back into preventing future cases, thereby directly influencing the other two missions.

Besides demonstrating how these missions are intimately linked, this example also explains why military health services have a significantly greater level of complexity than other health organisations that only have one mission, and accounts for the greater bureaucracy inherent to providing care for ADF patients compared to civilians. However, as previously indicated, at present JHC's 'treatment mission' is the only one to be recognised as such, and resourced accordingly, by the ADF and broader Defence and other government institutions.

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 paper contends that Arthur Graham Butler's history represents 20 years of historical analysis that identified what would now be referred to as the three elemental and enduring missions of military health services. Although Butler understandably describes them from a post-WWI Army perspective, this paper asserts that, although their implementation may differ, these missions remain relevant today to all three services in both peace and war. Butler also explains why military health services are inherently far more complex compared to their civilian counterparts. Therefore, it is unfortunate that only one of the missions identified by Butler is recognised as such and resourced accordingly.

These considerations explain why health care for military workforces should be provided by practitioners who are themselves under military discipline. They also support the contention that, in order to perform all three of the missions identified by Butler, the ADF's health services should be premised on an occupational-health-based systems model, with revised FIC that would lead to a genuinely holistic, sustainable and fit-for-purpose health services over the next 10–15 years.

Future articles will describe the FIC necessary to sustain the functions and roles described in previous articles in order to enable these missions.

Author

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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 other organisations mentioned.

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11 Productivity Commission Overview: A better way to support veterans and their families. 2019 Jul. 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.

12 Productivity Commission. RACP submission to the draft Productivity Commission report 'A Better Way to Support Veterans'. 2019 Feb. 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.

13 See 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 (FiC).

- Personnel;
- Organisation;
- Collective training;
- Facilities;
- Supplies;
- Major systems;
- Support, and
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Original Article

Can Communication Skills Training for Veteran's Spouses Increase Positive Communication Patterns?

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Abstract

Background: War veterans are at risk for lower relationship satisfaction and higher rates of separation and divorce. Addressing communication patterns between veteran's spouses is crucial in promoting family relationships and marriage stability.

Purpose: This study determines communication training's effect on communication patterns and positive feelings in veteran's spouses in Iran.

Material and methods: This quasi-experimental study was conducted on veteran spouses in the city of Najaf Abad, Iran. Ninety-six veteran spouses were selected and randomly assigned to experimental and control groups. The educational intervention was implemented only in the experimental group during six sessions. The communication patterns and positive feelings questionnaire were measured before the intervention and two months afterwards.

Results: After the intervention, the demand/withdraw pattern ($P = 0.02$) and mutual avoidance pattern ($P \geq 0.001$) were significantly lower in the intervention group than in the control group; however, the constructive communication pattern in the intervention group was significantly higher than the control group ($P = 0.01$). Also in the intervention group, women's positive feelings towards their spouse were significantly better than those of the control group ($P < 0.001$).

Conclusion: The finding provides evidence for the necessity of implementation of communication skills education in assistance services for veteran's wives.

Keywords: Constructive Communication Pattern, Mutual Avoidance Communication Pattern, Demand/Withdraw Communication Pattern, Veteran, Wives, Iran

Introduction

The Iran-Iraq war, which lasted eight years, was known as one of the catastrophes of human history in the twentieth century. In this war, more than 554 000 people became veterans.[1] The negative effects of war on veterans' health have been proven by numerous studies worldwide.[2, 3] As a result, veterans face significant and ongoing challenges with a high prevalence of adverse physical and psychological impacts.[3-5] The emotional and psychological problems unfavourably affect many aspects of the veteran's lives and put them at high risk for interpersonal problems, including lack of intimate relationships, partner aggression, parenting difficulties, lower marital satisfaction and divorce. For instance, there is evidence that veterans are at risk for lower relationship satisfaction and higher separation and divorce rates.[4-6]

Therefore, numerous research focuses on the effects of veterans' mental and physical symptoms on their partners and their relationships.[7, 8] As a result, the specific needs of veterans' family members, especially their spouses, have led to the development of various interventions to provide support in different forms with some promising results found.[9, 10]

In this respect, some studies showed that to promote proper family relationship and marriage stability, addressing couples' communication patterns is crucial.[11, 12]

There are three main kinds of communication patterns in couples: constructive communication, mutual avoidance, and demand/withdraw behaviour. These communication patterns are strongly associated with a varied range of relationship variables.[13, 14] Constructive communication is referred to positive behaviours that lead to promoting a cooperative approach to problem solving, understanding and engender trust. This type of communication is positively and strongly associated with marital satisfaction.[14] Mutual avoidance is referred to behaviours in which both partners avoid the conflict, for example, by changing the subject, becoming silent or walking away from each other.[15] Another pattern of communication behaviour is demand/withdraw, a dyadic pattern in which one partner complains, criticises, nags or tries to initiate change. In response, the other partner terminates, avoids or withdraws from the communication.[14] Contrary to constructive communication, mutual avoidance and demand/withdraw behaviour patterns sustain and intensify conflict and are associated with negative affects during and following communication between couples.[14]

Various research revealed that constructive communication pattern is critical for couple stability, forgiveness and marital satisfaction.[14, 16-19] In contrast, a study in Iran that compared communication patterns of veteran's and other person's spouses, revealed that veteran's spouses use constructive communication less and mutual avoidance and demand/withdraw more than other spouses.[20]

It is clear that for a family relationship to serve the much-needed support function for veterans, their spouse's communication patterns need to be recognised and addressed. Several studies have investigated the mental health of the veteran's spouses and their marital satisfaction in Iran;[9, 21] however, there has been less focus on their communication patterns. Furthermore, most of the studies in the Iranian veteran's family population focused on veterans with post-traumatic stress disorder (PTSD), but very few focused on veterans with other health difficulties.

To the best of the author's knowledge, no training has been developed for communication skills and positive feelings towards spouses that include veteran's in Iran. Hence, the present study focused exactly on training and reinforcing these behaviours to help veterans' spouses become more satisfied. The purpose of this study was to assess the effectiveness of the communication skills educational intervention. It was hypothesised that veteran's spouses would show significant increases in their positive feelings towards their spouse, constructive communication and decreases in negative communication after completing the educational intervention.

Materials and methods

Study design

This controlled quasi-experimental pre-test–post-test research was conducted in 2018 in Najaf Abad, one of the cities of Isfahan province in the centre of Iran.

Study participants

The study was performed at the 'Veterans Affairs' in Najaf Abad, from September to December 2018, on the spouses of veterans who met the inclusion criteria. According to the study's specific limitations, 150 females were selected from the target population by the convenience sampling method. Selected women were invited to participate in the study by phone call. The response rate was 73.3%. Interested women were evaluated for inclusion. The eligible participants were randomly assigned to either intervention (n = 48) or control (n = 48).

The included criteria were being willing to participate, being literate, experiencing at least two years of married life with the veteran and being a Najaf Abad resident. In addition, they could not have severe mental or physical disorders and must not have a history of drug abuse. The spouses of veterans with PTSD or drug abuse, and women who were absent more than two sessions from the educational sessions were excluded.

The Research Deputy of Isfahan University of Medical Sciences (397797) approved the study. The Ethics Committee of Isfahan University of Medical Sciences also approved the study proposal (ID code: IR.MUI.RESEARCH.REC.1398.238). The required permission was obtained from the Najaf Abad 'Veterans Affairs'. Before starting the study, the researcher explained the research protocol and objectives to the participants and assured them of data confidentiality and their ability to withdraw from the research at any phase. In addition, all participants and their spouses signed written informed consent. It is important to mention that after collecting post-test data at the end of the study, a briefing educational session was presented to the participants in the control group.

Data collection and educational intervention

Data collection tools in the study were self-report questionnaires as follows.

1. *The Demographic Information Checklist:* included age, number of marriages, duration of living with a veteran, level of education and number of family members.
2. *Communication Patterns Questionnaire (CPQ):* this self-report measure, developed by Sullaway and Christensen (1983), contains 35 Likert scale items. It evaluates how couples usually deal with their relationship problems at three periods: when a problem or challenge occurs, in the course of a problem or challenge, and after discussion of a problem. Each item assesses spouses' perception of how probable a specific type of behaviour occurs when faced with a relationship problem, from 1 (very improbable) to 9 (very probable). The subscales of CPQ has undergone numerous revisions since its development.[14] The study used the three-subscales scoring method[22] as follow: demand/withdraw behaviour, mutual avoidance and constructive communication. Higher scores on the demand/withdraw behaviour and mutual avoidance subscales indicate that negative communication patterns are in use; however, higher scores on the constructive communication subscale indicate that positive communication patterns are being used. For comparison, study scores of each pattern were set out of 100.

   The CPQ is freely available and one of the most commonly used in various studies that reported 0.74 to 0.78 of reliability for its subscales.[14] Also, in Iran, the previous study translated and normalised this measure and evaluated its validity and reliability. This study examined the correlation between the subscales of CPQ and the Marital Satisfaction Questionnaire. The correlation coefficients for constructive communication, mutual avoidance and demand/withdraw behaviour were 0.58, -0.58 and 0.35, respectively.[23] The reliability of the three subscales of CPQ was also measured by Alpha Cranach's method in the present study, as 0.79, 0.82 and 0.78, respectively.
3. *Positive Feelings Questionnaire (PFQ):* This self-report measure was developed and revised by O'Leary and her colleague (1983), is internally consistent, relatively stable over time in nonclinical groups, correlated with numerous significant measures of marital interaction and sensitive to changes during marital therapy.[23]

   The PFQ consists of 17 items in two segments. In the first segment (8 items), the participants are asked to determine their feelings towards their spouse on a scale of one (very negative) to seven (very positive). In the second segment (9 items), the participants are asked to select a phrase that best describes their overall feelings towards their spouse with numbers 1–7. Higher scores on the PFQ indicate feelings that are higher in positivity. The previous study in Iran translated and normalised this measure and evaluated its validity and reliability that was acceptable.[24]

Completing the mentioned tools took about 30 minutes. The participants in the intervention and control groups completed research tools before and two months after the intervention. During the questionnaires' completion, the instructor explained the importance of accurate answers to the answering of all questions.

The education was provided for women only in the experimental group and included lectures, group discussions, practice and role-playing.

This intervention was a 6-week group education that was designed to increase spouses' communication skills. The groups were conducted in a closed-group format, with 6–8 women in each group. The group atmosphere was nonconfrontational and supportive. Each 90-minute session contained brief didactic material, group activities and discussions, the practise of new behaviours, flexible time to explore change efforts and solve ongoing problems, and construct group unity.

Skilled instructors in the field of communication delivered the training. The communication skill training's intention was to increase positive communication patterns (constructive) while decreasing negative interactions (mutual avoidance and demand/withdrawn behaviours). Over six sessions, once a week, skilled instructors taught spouses practical communication skills. At the first session, the researchers wanted to produce rapid increases in relationship satisfaction that enabled women to engage in the more challenging work in their relationships. The instructors taught them ways to identify behaviours of their spouses that were positively reinforcing and worked to increase the instances of such behaviours. At the next sessions, the instructors taught participants to listen carefully and reflect on their spouse's words, confirm the words through their spouse's point of view, and understand and empathise with what their spouse might be experiencing emotionally. The instructors also taught participants such skills

Table 1 Comparison of demographic variables between intervention and control groups at the beginning of the study (N = 90, 100%)

Variable		Intervention	Control	P-value
Age	(years) Mean ± SD	45.4±7.3	43.8±7.7	[a]0.36
Family size	Mean ± SD	2.96±0.8	2.98±0.7	[a]0.89
Duration of living with a veteran	(years) Mean ± SD	18.6±5.5	19.4±5.2	[a]0.46
Education	Illiterate	0	1(2.1)	[b]0.9
	Below diploma	9(18.8)	11(2.2)	
	Diploma	22(45.8)	18(37.5)	
	Associate degree	15(31.2)	14(29.2)	
	Bachelor's degree	2(4.2)	4(8.3)	

[a] *independent t-tests (for quantitative variable)*
[b] *Chi-square 2 (for qualitative variable)*

Table 2 Comparison of communication patterns and positive feelings towards spouse mean scores between groups, before and after the intervention

	Variable	Groups	Time		P-value[a]
			Before intervention Mean ± SD	After intervention Mean ± SD	
Communication patterns CPQ	Constructive communication	Intervention	19.8±5.9	23.5±8.8	0.01
		Control	20.5±8.1	19.3±7.3	0.48
	P-value[b]		0.62	0.01	
	Mutual avoidance	Intervention	27.3±13.4	16.8±10.1	≤0.001
		Control	28.3±12.5	27.3±10.9	0.6
	P-value[b]		0.77	0.02	
	Demand/ withdraw	Intervention	26.4±7.1	22.4±8.8	0.009
		Control	25.9±10.2	26.4±7.6	0.76
	P-value[b]		0.72	≤0.001	
PFQ	Positive feelings towards spouse	Intervention	61.4±5.2	67.8±5.6	≤0.001
		Control	61.3±5.5	62.5±5.4	0.31
	P-value[b]		0.96	≤0.001	

[a] *Paired sample t-test*
[b] *Independent t-tests*

to increase empathic levels between them during emotional conversations and skills to help them stay calm and avoid negative interactions that can cause overwhelming emotions. The participants learned skills to request behaviour changes from their spouse in a manner that decrease resistance and reduce the pressure of the change requested. Finally, in the last session, the instructors showed the participants how to reduce their negative communication patterns such as mutual avoidance and demand/withdraw behaviour and the importance of increasing positive behaviours to enhance relationship satisfaction levels. During each session, by engaging in group work, participants had a good chance to listen and pay attention to others and share similar communications skills experiences. Participants could alter their family conditions and gain support and confirmation for their practices to become more confident.

During the post-intervening interval, the instructors answered participant's questions by email, text messages and phone calls. Two months later, the participants (both experimental and control groups) were invited to complete the research tools again.

Statistical analysis

The researcher analysed the data by the IBM SPSS/21.0 (IBM Corp., Armonk, NY, USA) through descriptive statistics, such as frequency, mean and standard deviation, and inferential statistics, such as paired and independent t-tests, Chi-Square, the Fisher's Exact Test, as well as one-way analysis of variance (ANOVA). They confirmed the normality of data using the Kolmogorov-Smirnov test. The level of significance was $P = 0.05$.

Results

The participants mean age in the intervention and control groups was 45.4±7.3 and 43.8±7.7 years, respectively. Almost all of them were homemakers. As shown in Table 1, participants in the intervention and control groups were comparable on demographic variables such as age, duration of living with a veteran, level of education and number of family members. In addition, as shown in Table 2, t-tests revealed no significant differences between the study groups in the main study variables (communication patterns and positive feelings towards spouse) at the pre-test ($P \leq 0.05$).

To understand the effect of the educational intervention on participating women from pre to post-intervention, we used paired sample t-tests. Table 2 summarised the subscale mean scores for the study groups.

Participant scores on the constructive communication subscale revealed a statistically significant increase in the intervention group from pre-test to post-test ($P < 0.05$), but no significant differences were found from pre-test to post-test in the control group. In addition, the mean score of the mutual avoidance subscale revealed a statistically significant decrease in the intervention group after the intervention (27.3±13.4versus16.8±10.1; $P < 0.001$) as well as a significant decrease was seen in the demand/ withdraw subscale ($P < 0.05$).

As shown in Table 2, the post-test results also showed that the participant's positive feelings towards their spouse in the intervention group was significantly better than that of the control group ($P < 0.001$).

Discussion

The study's first aim was to examine whether communication patterns changed two mounts after the educational intervention. Since previous research revealed that Iranian veteran families lack the necessary communication skills and, as a result, engage in excessive negative behaviour and limited positive communication behaviours,[20] the educational intervention focused on increasing positive communication behaviours and decreasing negative ones. During the educational intervention, spouses were taught ways to more effectively communicate by using both listener skills (e.g. paraphrasing) and speaker skills (e.g. using 'I' statements instead of blaming 'you' statements).

The results showed that the intervention group evidenced a significant increase in positive communication patterns (constructive) from pre-test to two months after intervention than did the control group. In addition, intervention participants used fewer negative interactions (mutual avoidance and demand/withdrawn behaviour) than the control participants.

The significant changes in the communication patterns of the intervention group after the education was consistent with the results of Schmidt et al.[22] Results were also consistent with the findings of a study in Iranian PTSD veterans and their spouses, indicating that emotionally focused couple therapy results in a decrease in mutual avoidance, demand/ withdrawal, and an increase in constructive communication patterns.[25]

The present study provides introductory support for the efficacy of communication skills as an intervention to reduce negative interactions and increase positive ones in veteran spouses. Practical communication skills enable spouses to use a more sustainable and effective communication form to exchange accurate messages and effectively manage familial disagreements and conflicts. Positive communication between couples allows them to discuss and exchange ideas and be aware of their needs.[26]

According to a previous study, group educations are regularly delivered for military veteran couples. Despite considerable expressed interest in potential referral sources, only a relatively small percentage of eligible couples engaged in the educational sessions.[27] One pilot study showed veterans themselves want to preserve their relationships and seek assistance to do so but are reluctant to participate in educational intervention for different reasons. They described some as physical and mental difficulties, work scheduling conflicts, and issues related to social stigma and fear of discussing and sharing family conflict and relationship problems with other military couples. However, their wives were eager to learn new skills, such as communications skills. Likewise, Eaton and colleague's study revealed that although spouses of military service members had similar rates of mental health problems than soldiers, they were more likely to seek care for their problems and were less concerned with the stigma than were soldiers.[28] Therefore, the present study, did not offer the veterans themselves any communication training as part of this intervention. This research aimed to examine if communication skills training for veteran's spouses can change their communication patterns. We were able to successfully recruit from the veteran's spouse population to fill the intervention groups—all but three of the women that began the group interventions completed them.

Another goal of the present study was to examine whether communication skills training could increase women's positive feelings towards their spouses as an indicator of relationship satisfaction. Consistent with our hypothesis, the results showed that changes in positive feelings toward their spouses two months after the intervention were only significant in the intervention group.

According to a relatively old study, women's positive feelings towards a spouse is relatively difficult to define and measure as the most important characteristic of a worthy marriage.[23] Earlier research in Iranian couples revealed that spouse's positive feelings are significantly strongly associated with important relationship variables.[24]

Similar to our results, numerous studies have confirmed the beneficial effects of family communication skills training. For instance, the study by Pardar indicated that after communication skills training, self-efficacy and hopefulness of veterans' spouses were significantly increased.[26]

Likewise, Tavakolizadeh's study revealed that communication skills training for couples could significantly reduce marital conflicts and lead to robust pair bonding and more emotional expression, especially positive.[29] In addition, Ghazavi and colleagues' study revealed that communication skills training enables individuals to begin more effective interactions, whereby they can exchange accurate messages and effectively manage familial disagreements and conflicts, therefore be happy in family life.[30]

There are several limitations to the current study. First, we could not attract the veteran's participation. It is recommended that both couples attend educational intervention and participate in the study. Second, it is difficult to generalise our findings to the Iranian veteran's spouse population because the sample was limited to veteran's spouses of Najaf Abad.

Additional research with a larger and more varied sample is needed to provide accurate evidence of the communication skills training efficacy. Third, this study purposefully analysed self-report data. It is better to examine changes in communication patterns and the link between communication patterns and positive affect outcomes—observational methods such as video-recorded interactions may be used. Finally, this research's most significant limitation was the lack of long time follow-up to evaluate the continuity of educational outcomes after the intervention. This study's findings are encouraging for those providing services to veterans' family, bearing in mind the limitations. This training format, delivering communication skills training only for veteran's spouses, can change their communication patterns and is more feasible and uses less time and resources than couple-based interventions.

Conclusion

After the education, participants significantly increased their positive feelings toward their husbands, decreased the use of negative communication patterns, and increased communication patterns involving positive interactions. These findings indicate that veteran's spouses who learn and practice communication skills and learn the important role of empathy between couples during emotional conversations can successfully incorporate what they have learned into their relationship.

This study demonstrated the feasibility of recruiting from veteran's spouse population and the feasibility of attendance for 6-week group education. The results were promising for promoting communication patterns and positive feelings toward husbands in veterans' spouses and provide the initial basis for future research on communication patterns and intimate relationships.

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Causes and Diseases Leading to Early Permanent Medical Disqualification of Military Non-Pilot Flight Crews Based on Their Service Categories

H Shahali, A Amirabadi Farahani

Abstract

Background: Efficient workforce is the most important capital, and studies have shown apositive relationship between health and performance. Understanding the factors leading to disability has preventive importance.

Purpose: Determine the causes and diseases leading to early permanent medical disqualification of Iran air force non-pilot flight crews based on their service categories from 1986 to 2016.

Materials and methods: The study was designed as a descriptive, cross-sectional, retrospective investigation. The data were collected from Iran air force medical records and medical council files, sorted in a predesigned electronic sheet.

Results: Out of 228 cases of early medical discharges, 181 items were considered a medical disqualification, and the remaining 47 was for on service killed persons. The main causes were psychiatric, neurologic and otorhinolaryngeal, while common diseases include generalisedanxiety disorder, occupational hearing loss and myocardial infarction. The lost service years were 2457person-years, and the average was 13.57person-years per individual.

Conclusion: Due to close similarities of pilots and non-pilot flight crews in the occupational environment, we expected that the results in pilots were referable to non-pilot flight crews but found they differed. The preparation of a flight crew requires many resources that are wasted with disability.

Keywords: Disabilities, disqualification, health, prevention, performance

Conflict of Interest: None

Introduction

Human resources are the most important capital of armed forces, and many studies have shown the strong links between personal health and organisational performance.To increase productivity, organisations have adopted numerous measures to evaluate preemployment health statusand monitor staff health during their service life. Nonetheless, health risks remain the most important reducing factor of personal productivity. Disability is defined as the effect of a disorder on a person's physical, mental and social activity where the work environment and the family status are also effective elements.[1-3] According to statistics, effective prevention of cardiovascular risk factors in the aviation population has a significant role in improving aviators' professional health index. The study of aviators' work environment and lifestyle, active intervention, regular periodic examinations and screening tests for early detection of diseases are among the basic measures.[9]

These days, the economic, mental and social problems caused by disability in armed forces are critical. Regardless of the huge cost to run and maintain a powerful army, the supportive burden of victims can be devastating for any society.[20] In 1993, the United States (US) army paid 500 million dollars of compensation to newly recruited armed forces.[6,7]A study conducted between 1980 and 1994 on the causes of disability in US air and sea forcesshowedhow disability in armed forces led to a high cost (about 1.5 billion dollars)incompensation.[1] With an annual budget of more than $200USD billion in 2019, the US Department of Veterans Affairs (VA) is the largest single healthcare provider and administers an extensive disability compensation program. For Vietnam Veterans with VA service-connected disabilities, the total fiscal year 2013 expenditures for VA disability compensation and medical care exceeded $22USD billion: $15.7 billion was spent on disability compensation payments and $7.1USD billion on medical care.[17]

The Federal Aviation Administration (FAA) conducted a large comprehensive study in 2014 on the causes of medical disqualification of pilots, listing 15 major causes, including angina pectoris, bipolar disorder, cardiac valve replacement, coronaryartery diseases, diabetes mellitus, loss of consciousness with unknown reason, seizure, myocardial infarction, permanent pacemaker, disabling personal disorder, psychosis, drug abuse and dependency, and lack of neural control(in order of significance).[15]

The preparation of military non-pilot volunteers to enter professional training and the provision of optimal services in the form of well-trained non-pilot flight crews (NPFC) require a considerable amount of resources, both physical and intellectual.

The present study'sultimate goal was to determine the causes and diseases that led to early permanent medical disqualification (EPMD) of IranAir Force (IRIAF) NPFC based on their service categories from 1986 to 2016. Other objectives include determining the exact number of NPFC killed in IRIAF, the lost service years (LSY) in IRIAF NPFC with EPMD (including four years of training and a total service duration of 30 years in IRIAF), the average LSY for IRIAF NPFC with EPMD and the provision of a scientific and practical solution to prevent the EPMD of IRIAF NPFC, based on their service categories.

Materials and methods

This study is descriptive, cross-sectionalretrospective research.The target population was the IRIAF NPFC with EPMD from 1986 to 2016. NPFC in the IRIAF included service categories as flight engineer, navigator, crew chief, loadmaster, air trafficcontroller, mechanic, flight security, hostess, air operation, boom operation and martial control. All IRIAF NPFC with medical disqualifications from 1986 to 2016 were selected, whose relevant official records had been documented during multiple medical sessions. However, NPFC with disqualification due to physical or mental illness and death in non-occupational accidents, non-medical reasons, personal requests or disciplinary punishments were excluded from the study. This study's ethical approval was issued by the Ethics Committee of the Aerospace and Sub-aquatic Medical Faculty, Aja University of Medical Sciences, with registration No: 10167105. The study was financed personallyby the corresponding author, and no governmental or military funding was provided.

After intense coordination with relevant authorities in IRIAF's Department of Health, Medical Education and Services to obtain necessary permissions of unlimited access to designated medical records, focusing on the data's confidentiality aspects, the archivist assigned a non-disclosed random ID code to each record. Leading causes and diseases leading to EPMD, based on the 10th version of the International Classification of Diseases(ICD-10), were then read out of paper documents and entered into a Microsoft excel-based predesigned electronic data form along with other demographic information, including dates of entry into and departure from the service,and service categories. In a few cases, where more than one reason for EPMD, only the leading cause was considered.The tabulated information was sorted and summarised based on each service category with total LSY, and average LSY. The data were displayed in graph and figure format. Like other up-to-date military articles, we are reluctant to disclose a number of confidential military information (i.e. total number of cases).

Results

From 1986 to 2016, 228 cases of early permanent discharges were registered, including 47(20.6%) killed or missed in action and 181(79.4%) EPMD. The data are given in Table 1.

Among 16 total causes of EPMD in IRIAF NPFC, the most common causes included psychiatric, neurologic, otorhinolaryngeal, cardiac, neurosurgery and other causes in order of importance. The prevalence of the leadingcauses is depicted in Table 2. Of 74 EPMD diseases in IRIAF NPFC, the most prevalent diseases included generalised anxiety disorder, occupational hearing loss, myocardial infarction, lumbar discopathy, renal colic with multiple stones, and other diseases, shown in Table 3 (based on their service categories).

Total LSY in IRIAF NPFC was 2457person-years, where the most common causes were psychiatric, neurologic and neurosurgery, in origin, more details of which are displayed in Table 4. The top three diseases incurring greater LSY on IRIAF were generalised anxiety disorder, occupational hearing loss and migraine. The number of total LSYbased on each specified disease's service categories is shown in Table 5. The average LSY in IRIAF NPFC with EPMD was 13.57person-years per individual, and the statistics were illustrated numerically in Tables 6.a and 6.b.

Tables:

Table 1: Demographic study data

	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight security	Hostess	Air operation	Boom operation	Martial control	Sum
EPMD[1]	35	32	27	26	22	10	9	6	5	3	6	181
killed	3	12	4	5	4	3	5	2	4	3	2	47
Sum	38	44	31	31	26	13	14	8	9	6	8	228

1- EPMD: Early and Permanent Medical Disqualification

Table 2: Common causes of EPMD[1] of IRIAF[2] NPFC[3]

Occupation / Cause	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight security	Hostess	Air operation	Boom operation	Martial control	Sum
Psychiatric	8	7	5	4	2	2	2	0	0	0	1	31
Neurologic	8	4	2	2	1	0	2	2	1	0	0	22
ENT[4]	2	3	3	3	5	2	2	0	0	0	0	20
Caradic	4	6	1	1	2	1	0	1	1	1	0	18
Neurosurgery	4	1	6	3	0	1	2	0	1	0	0	18
Other causes	17	13	10	12	7	3	2	1	1	2	4	72
												181

1- EPMD: Early and Permanent Medical Disqualification

2- IRIAF: IRAN Air Force

3- NPFC: Non-Pilot Flight Crews

4- ENT: Ear, Nose and Throat

Table 3: Common diseases leading to the EPMD[1] of IRIAF[2] NPFC[3]

Occupation / Cause	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight security	Hostess	Air operation	Boom operation	Martial control	Sum
Generalised anxiety disorder	3	2	0	1	1	2	0	0	0	2	1	12
Occupational hearing loss	1	1	0	3	3	1	2	0	0	0	0	11
Myocardial infarction	1	2	3	1	0	0	0	1	1	0	0	9
Lumbar discopathy	2	0	3	1	0	0	1	0	1	0	0	8
Renal colic with multiple stones	0	3	1	0	2	1	0	0	0	0	0	7
Other diseases	28	24	20	20	16	6	6	5	3	1	5	134
												181

1- EPMD: Early and Permanent Medical Disqualification

2- IRIAF: IRAN Air Force

3- NPFC: Non-Pilot Flight Crews

Table 4: Causes of LSY[1] of IRIAF[2] NPFC[3] with EPMD[4]

Occupation / Cause	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight security	Hostess	Air operation	Boom operation	Martial control	Sum
Psychiatric	104	73	43	90	27	47	0	0	0	15	12	411
Neurologic	157	53	0	24	5	0	40	16	5	0	0	300
Neurosurgery	34	4	71	43	8	47	24	0	13	0	0	244
Other causes	155	244	191	252	237	90	119	104	41	22	47	1502
												2457

1-LSY: Lost Service Years

2-IRIAF: IRAN Air Force

3-NPFC: Non-Pilot Flight Crews

4-EPMD: Early and Permanent Medical Disqualification

Table 5: Diseases of LSY[1] of IRIAF[2] NPFC[3] with EPMD[4]

Occupation / Cause	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight security	Hostess	Air operation	Boom operation	Martial control	Sum
Generalise anxiety disorder	49	30	0	27	8	47	0	0	0	15	12	188
Occupational hearing loss	1	17	0	42	35	17	40	0	0	0	0	152
Migraine	97	15	0	0	0	0	0	0	0	0	0	112
Renal colic with multiple stones	0	39	21	0	21	19	0	0	0	0	0	100
Diabetic miletus	3	10	28	32	10	14	0	0	0	0	0	97
Others diseases	300	263	256	308	203	87	143	120	59	22	47	1808
												2457

1-LSY: Lost Service Years
2-IRIAF: IRAN Air Force
3-NPFC: Non-Pilot Flight Crews
4-EPMD: Early and Permanent Medical Disqualification

Table 6.a: Average of LSY[1] of IRIAF[2] NPFC[3] with EPMD[4] according to causes

Occupation / Cause	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight security	Hostess	Air operation	Boom operation	Martial control
Psychiatric	17.21	11	14.34	22.5	13.5	23.5	0	0	0	7.5	12
Orthopedic	9.75	0	13.25	13.75	13	10	0	22.5	14	0	19
Oncologic	0	9	11.5	5	19	0	22	19	0	0	0
Other causes	9	10.52	12.45	11.3	10.26	9	14.2	17.75	11.25	7	0

1-LSY: Lost Service Years
2-IRIAF: IRAN Air Force
3-NPFC: Non-Pilot Flight Crews
4-EPMD: Early and Permanent Medical Disqualification

Table 6.b: Average LSY[1] of IRIAF[2] NPFC[3] with EPMD[4] according to diseases

Occupation / Cause	Flight engineer	Navigator	Crew chief	Load master	Air traffic controller	Mechanic	Flight securit y	Hostess	Air operation	Boom operation	Martial control
Specific flight phobia	26.02	0	0	0	0	0	0	0	0	0	0
Migraine	24.25	15	0	0	0	0	0	0	0	0	0
Psychosis	5	15	28	19	0	0	0	0	0	0	0
Renal colic with multiple stones	0	13	21	0	10.5	19	0	0	0	0	0
Generalised anxiety disorder	16.34	15	0	27	8	23.5	0	0	0	7.5	12
Other diseases	8.6	9.38	9.89	10.4	10.84	15.5	17.5	18	10.5	0	0

1-LSY: Lost Service Years
2-IRIAF: IRAN Air Force
3-NPFC: Non-Pilot Flight Crews
4-EPMD: Early and Permanent Medical Disqualification

Discussion

Civil and military NPFC play a significant role in the aeronautics industry of Iran and the world. Together with their pilot colleagues, they guarantee the safety, health and comfort of the community. Preparing flight crew to enter professional training courses and delivering desirable services in the form of expert military aviators demands extreme capital and personal costs. Accordingly, any disqualification will be a major loss of funding and human capital for armed forces. Thus, control of this needs effective prevention.[1-5]

The timely cognition and precise determination of the prevalence and causes of diseases leading to their EPMD may lead to the design and development of effective methods for diagnosis, prevention, treatment and rehabilitation. Unfortunately, studies reporting civil or military NPFC throughout the world are scarce, and the present investigation is an exclusive study to encourage researchers to do similar studies in the field.

The main reasons for EPMD of IRIAF NPFC during the study included psychiatric, neurologic, otorhinolaryngeal, cardiac and orthopaedic disorders. In any armed forces, while in drills or real battle, casualties are inevitable and killed NPFC are not considered to be among the lost years of service and are assumed as missed data.

Since similar studies in Iran and the world have not been designed with the same duration and target population, findings of this study can be compared with the results of studies performed in similar populations in other countries due to the dissimilarities of the work environment (i.e. the cabin condition) of the pilot and non-pilot flight personnel. Indeed, as the differences in flying devices and working conditions of flight personnel in different countries, it seems reasonable to simultaneously express the findings of studies in Iran and other countries.

In a study by Montazeri(2005), the most common causes for EPMD of IRIAF pilots were cardiovascular and neuro-skeletal irregularities.[19] In Ghazizade's (2010) study, cardiovascular, neuroskeletal and digestive causes were more common in the same population, but involved different samples between 1992 and 2003.[18] The diseases that led to the pilots' medical disqualification were not assessed. However, both studies were conducted on pilots only and the duration of studies was less than a decade in both cases.

In a study on US Air Force pilots and navigators (USAF) by Whitton(1984), common causes were cardiovascular and neurological,[16] while in a survey by McCrayry(2002) on a similar population between 1995 and 1999, the most common causes were cardiovascular, musculoskeletal, neurologic and endocrine disorders.[11] In Dark's study (1986), with the help of the FAA to disqualify American airline pilots between 1983and 1984, the most common causes were cardiovascular and neuropsychiatric events.[18] In the study by Nakanishi (2003), 260 Japanese crew members with a permanent disability, the most important causes included malignancies, neuropsychiatric disorders, cardiovascular, gastrointestinal and musculoskeletal disorders.[8] In a study in Commonwealth countries on disqualified pilots between 1994 to 2004, cardiopulmonary disorders were the leading cause.[18] In Arva's study (2004), Regarding the 257 Norwegian civilian pilots, the main causes include cardiovascular, neurological, musculoskeletal and psychiatric diseases.[10] In both studies by Mitchell (2004) and Evan (2006), investigations on the sudden incapacitation of British Civilian Pilots from 36 incidents, half were caused by cardiac or cerebrovascular accidents, and mental disorders were one of the leading causes.[12,13] In Nezami's research on 200 civilian pilots of Vnukovo airport (Moscow), cardiovascular, nervous and digestive causes were the leading causes of disqualification.[9] In summary, cardiovascular, neurological and musculoskeletal causes are the most common causes of medical disqualification in these studies.

Common diseases leading to EPMD in IRIAF NPFC during the present 30-year study included generalised anxiety disorder, occupational hearing loss, myocardial infarction, lumbar discopathy and renal colic with multiple stones. However, in McChary's (2002) review of USAF pilots and navigators in 1995–1999, more common diseases were ischaemic heart disease, high blood pressure, back pain, intervertebral disc and migraine disorder.[11] In the 2011 study of Nezami, on 200 civilian pilots in Vnukovo airport, ischaemic heart disease, myocardial infarction, high blood pressure, atherosclerotic lesions of the cerebrovascular and peptic ulcers were most common.[9] In our study, myocardial infarction was one of the most common diseases.

In February 2014, the FAA published a statement on its official website as'FAA's 15 disqualifying aviation medical conditions for prospective pilots', five of the most common being angina pectoris, bipolar disease, cardiac valve replacement, coronary heart disease and diabetes mellitus.[15] However, these are for pilots and may be expandable to NPFC.

The total LSY was 2457person-years, the highest rates related to psychiatric, neurologic and neurosurgery causes. The diseases with the most LSY burden included generalised anxiety disorder, occupational hearing loss and migraine. The average LSY was 13.57person-years per individual, and the highest were due to psychiatric, orthopaedic and oncologic causes, as well as flight phobia, migraine and psychosis. In Montazeri's (2005) study, the mean LSY in IRIAF's medical retired personnel with EPMD was 6.6 person-years.[19] In the Ghazizade study conducted for disabled persons at the IRIAF hospital from 1992 to 2003, the average LSY were 6.14person-years per individual. The highest figure was 10 person-years.[18]

The limitations of the present study include:

1.)missing details due to the lack of presence of a comprehensive electronic system for recording personal medical records
2. the possibility of oriented malingering in disorders where specific objective diagnosticmethods are not available and were mostly diagnosed subjectively, such as motion sickness, migraine, irritable bowel syndrome etc.
3. flying device factors (ergonomics and exhaustion), operational and airbase factors (work and rest schedule), personal factors (lifestyle, physical and psychological capabilities, socioeconomic state, use of legal and illicit drugs and habits), medical factors (medical and psychological advices and hygiene education) which have effective influence on cadet health.

The present investigation has important advantages such as:

1. being the first reported study on EPMD of military NPFC
2. the longest cross-sectional period (35 years)—the closest was performed during a 10-year period[18]
3. express the statistics of IRIAF killed NPFC
4. records were sorted according to the service categories.

More studies should be conducted on military and civil NPFC in the future as we believe that lifestyle modifications, regular fitness training, hygiene and health education, and medical and psychological counselling for preventing the EPMD in military NPFC are necessary preventive steps to take. The authors also recommend usingup-to-date comprehensive electronic systems, upgrading on-the-job examinations, sufficient periodic in-service examinations in occupational health centres. Unfortunately, there has not been a similar military study published with worldwide data so far, making it necessary to accomplish this research more effectively and strategically.

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Ethical approval

This study's ethical approval was issued by the Ethics Committee of the Aerospace and Sub-aquatic Medical Faculty in Aja University of Medical Sciences, with registration No: 10167105.

Abbreviations

NPFC: non-pilot flight crews

EPMD:early permanent medical disqualification

IRIAF: Iran air force

LSY: lost service years

US:United States

USAF: United States Air Force

FAA:Federal Aviation Association

ICD-10: international classification of diseases

Contributorship:

Dr Azade Amirabadi Farahani, MD,was my main teammate and was involved in searching for similar studies, data collection and statistical analysis as an erudite researcher. I would like to introduce her as my co-author.

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Effect of Socio-Demographic and Health Indices on the Survival of Cancer Patients Among the Iranian Military Community: A Survival Analysis

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Abstract

Background: Concurrent to changes in lifestyles, non-communicable diseases such as cancers are one of the main causes of mortality. Identifying effective factors on the survival status of cancer patients is essential for health practitioners.

Purpose: The current study aimed to investigate the effect of sociodemographic and health indices on cancer survival among the Iranian military community (MC).

Material and methods: The required data were extracted from the registered cases in the Iranian MC insurance organisation. The Kaplan-Meier method, logrank test and Cox proportional hazard regression model were used to analyse data. All analyses performed using SPSS 22.

Results: Overall, 31 657 cancer cases were registered during the understudied period. In total, 14 698 (46.4%) and 16 959 (54.6%) of cases were males and females, respectively. The median survival time among males and females was 5.58 years (95% CI: 5.32–5.84) 11.41 years (95% CI: 10.70–12.12, P<0.001), respectively. The hazard ratio for gender (female) was 0.54 (95% CI: 0.51–0.56, P<0.001) and for age was 1.08 (95% CI: 1.03–1.14, P<0.001). The number of rural, urban and active health centres, hospitals and hospital beds, clinics and physicians and the HDI did not show a significant effect on the risk of death of cancer patients (P>0.05).

Conclusion: It seems that the coverage of health services in all provinces of Iran is the same, and the inequality is few. However, other variables such as age and gender are influential factors in cancer deaths.

Keywords: Survival analysis, cancers, Iranian military

Conflict of interest: The authors did not have any competing interests

Introduction

The global burden of disease has changed in both developed and developing countries over the past century, and the pattern of disease has shifted from infectious to non-communicable.[1] Cancer is one of the most important non-communicable disease and the second leading cause of death and disability globally, with about 17.5 million new cases per year and 8.7 million deaths annually. It has placed a heavy burden on health systems.[2] The increasing incidence of non-communicable diseases is affected by population ageing, sedentary lifestyle, stress and increased unhealthy behaviours (such as cigarette smoking and unhealthy diet).[3]

Lung, breast and colorectal cancers are the most common cancers in the world.[4] In addition, prostate cancer is the most common cancer among men, and breast cancer is the most common cancer in women.[5] In Iran, cancer is the third cause of mortality after coronary heart disease and injuries, and cancer incidence has an increasing trend.[3,6,7] This increasing trend is affected by different causes. For example, stress is an influential factor in the occurrence of many non-communicable diseases, including cancer.

Military personnel and communities are exposed to higher levels of job stress than other groups due to the nature of their job and high risk of stressful conditions.[8-10] Compared to the general population, the military community (MC) may not have adequate access to health services due to their occupational conditions, leading to late diagnosis, worsening disease prognosis and increased mortality. Thus, the distribution of health services, such as hospitals and primary healthcare centres has an important role in reducing deaths. The human development index (HDI) is one of the main indicators that reveal the level of development of societies. This indicator comprises three factors that can affect morbidity and mortality, including life expectancy at birth, gross national income per capita, and mean and expected years of schooling. Identifying factors affecting the survival of cancer patients can be very helpful for designing prevention programs. Most studies focused on cancer survival investigate the general population. Because of the probable effect of socioeconomic, sociodemographic and health indices on cancer survival among the Iranian MC and lack of similar studies, the current study aimed to investigate and identify the effect of sociodemographic factors and health indices on cancer survival among the Iranian MC.

Materials and methods

Data

In this retrospective study, the required data on cancer patients were extracted from the Iranian MC insurance organisation's registered cases. These data included variables such as age, gender, type of cancer, time of diagnosis (month and year), and patients' last status (alive or deceased). All registered cancers in the Iranian MC (active, retired, family, veterans) diagnosed and registered from March 2007 to March 2017 were entered into this study. Also, other data such as the number of rural, urban and active health centres, hospitals and hospital beds, clinics, HDI and the number of physicians in different provinces of Iran were extracted from Iran's statistical centre. First, all data were entered into Excel, and after cleaning, they provided the main analysis.

Statistical analysis

Descriptive analyses of the variables were expressed as mean (±Standard Deviation = SD), median, number and proportion (%). The Kaplan-Meier method was used to show survival for a period after cancer diagnosis among patients; also, the logrank test was used to compare survival between two genders. To investigate the effect of the explanatory variables such as age, gender, HDI, number of hospitals, physicians and rural health centres in different provinces, etc. on survival time, a Cox proportional hazards regression model was used. Also, the adjusted hazard ratio (HR) as a measure of association with 95% confidence interval (CI) was calculated. The analysis excluded missing data. All P-values are based on two-tailed tests, and a P-value less than 0.05 was considered statistically significant. The data were analysed using SPSS version 22.0.

Ethics approval

This study was registered and approved by the Ethical Committee of the AJA University of Medical Sciences (IR.AJAUMS.REC.1398.241).

Results

Overall, 31 657 cancer cases were registered during the understudied period. The mean age of cases was 63.45 ± 15.24 years. Five-thousand and three (15.8%) of total cases occurred in individuals less than 50 years old, and 26 653 (84.2%) of cases occurred among more than 50 years (more information is shown in Table 1). About 9017 (28.5%) of cases died during the mentioned period. Overall, 5298 (58.8%) deaths occurred among males, and 3719 (41.2%) deaths occurred among females. The information about the more prevalent cancers and the number of deaths among the Iranian MC can be seen in Table 2. The median survival time among all cancer patients was 8.37 years (95% CI: 8.02–8.71) (see Figure 1). In total, 14 698 (46.4%) cases were male, and 16 959 (54.6%) cases were female. The median survival time among male patients was 5.58 years (95% CI: 5.32–5.84) and among female patients was 11.41 years (95% CI: 10.70–12.12). There were significant differences between males and females in the survival time (P<0.001) (see Figure 2). The median survival time among pensioners, retired and employed cases was 3.29 year (95% CI: 3.11–3.46), 14.33 year (95% CI: 13.50–15.16), 7.23 years (95% CI: 6.47–7.99), respectively, and there was a significant difference between different job status about the survival time (P<0.001). More information is shown in Table 3.

According to the result of Cox regression, the HR for gender (female) was 0.54 (95% CI: 0.51–0.56, P<0.001). The HR for age was 1.08 (95% CI: 1.03–1.14, P<0.001). It means that the death hazard in females was 0.54 (95% CI: 0.51–0.56) times lower than males (46%). Increasing one year of age increased death hazard by 1.08 times (95% CI: 1.03–1.14). The HR of cancer death among retired and

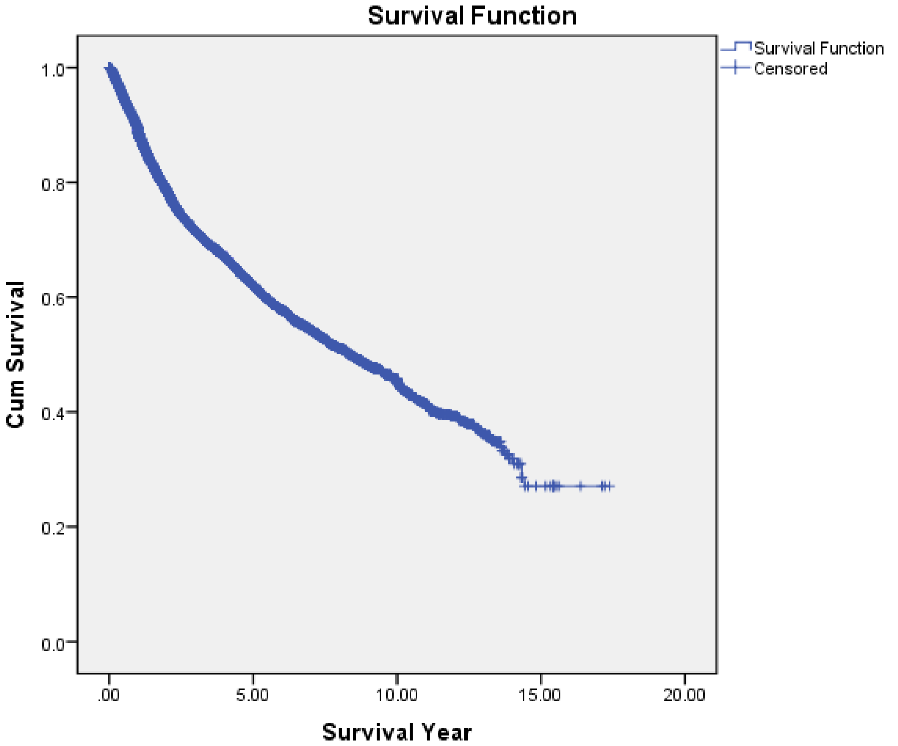

Figure 1. The survival function of all types of cancers among the Iranian military community

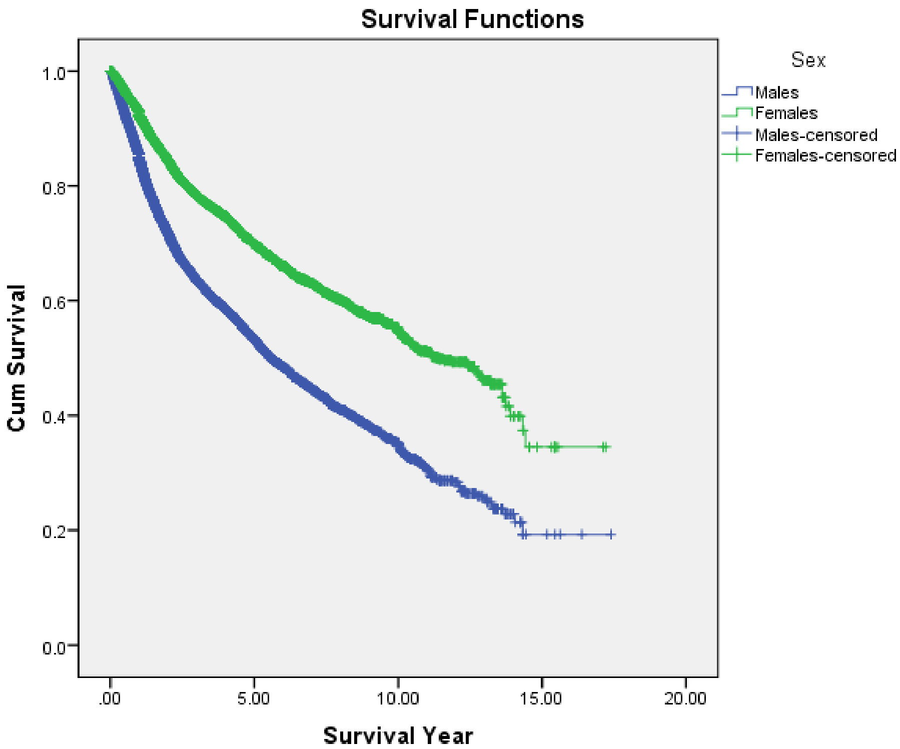

Figure 2. The survival functions of all types of cancers among the Iranian military community, according to gender

employed patients compared with pensioners was 0.05 (95% CI: 0.001–0.7, P=0.03) and 0.001 (95% CI: 0.0001–15.53, P=0.16), respectively. The HDI, number of rural, urban and active health centres, hospitals and hospital beds, clinics, and physicians did not show a significant effect on the risk of death for cancer patients (Table 4). This shows that the difference in the mentioned factors between different provinces and the Iranian MC was not significant.

Table 1. The frequency of cancer cases according to some variables

Variable	N (%)
Gender	
Male	14698 (46.6)
Female	16959 (53.6)
Job status	
Pensioner	8189 (25.9)
Retired	18480 (58.4)
Employed	4988 (15.8)
Age	
≤50	5003 (15.8)
>50	26653 (84.2)
Overall	31657

Table 2. Most prevalent cancers and the number of deaths due to each type of cancer among the Iranian military community

Type of cancer	N (%)	Number of deaths (%)
Breast	8320 (0.26)	977 (0.11)
Prostate	3059 (0.10)	725 (0.08)
Colon	2307 (0.07)	650 (0.07)
Stomach	1823 (0.06)	982 (0.11)
Bladder	1467 (0.05)	407 (0.05)
Ovarian	765 (0.02)	233 (0.03)
Lung	692 (0.02)	618 (0.07)
Brain	545 (0.02)	397 (0.04)
Rectum	536 (0.02)	310 (0.03)
Other cancers	12143 (0.38)	3718 (0.41)
Total	31657 (100)	9017 (100)

Table 3. The estimates of mean and median of survival time according to gender and job status in Iranian military community

Variables	Mean				Median				p
	Estimate	SE	95% CI		Estimate	SE	95% CI		
			Lower bound	Upper bound			Lower bound	Upper bound	
Gender									
Male	7.48	0.14	7.21	7.75	5.58	0.13	5.32	5.84	<0.001
Female	10.31	0.17	9.98	10.64	11.41	0.36	10.70	12.12	
Job status									
Pensioner	5.07	0.10	4.87	5.27	3.29	0.09	3.11	3.46	<0.001
Retired	11.57	0.19	11.20	11.94	14.33	0.42	13.50	15.16	
Employed	8.72	0.22	8.29	9.15	7.23	0.39	6.47	7.99	
Overall	8.99	0.11	8.77	9.22	8.37	0.18	8.02	8.72	

Table 4. Factors associated with the cancer mortality among Iranian military community

Variables	B	SE	Wald	df	P	Exp (B)	95.0% CI for Exp(B)	
							Lower	Upper
Gender (females)	-0.61	0.21	5.42	1.00	0.001	0.54	0.51	0.56
Age	0.08	0.03	8.55	1.00	0.001	1.08	1.03	1.14
Number of rural health centres	-1.07	1.08	0.97	1.00	0.32	0.34	0.04	2.87
Number of urban health centres	-0.71	0.75	0.88	1.00	0.35	0.49	0.11	2.16
Number of active rural health centres	0.27	1.03	0.07	1.00	0.79	1.31	0.18	9.79
Number of hospitals	0.58	2.02	0.08	1.00	0.78	1.78	0.03	93.70
Number of hospital beds	-0.80	1.07	0.56	1.00	0.45	0.45	0.06	3.63
Number of clinics	-0.07	1.30	0.00	1.00	0.96	0.94	0.07	11.92
HDI	0.22	0.80	0.08	1.00	0.78	1.25	0.26	5.96
Number of literacy	-0.35	1.60	0.05	1.00	0.83	0.71	0.03	16.29
Number of physicians	1.07	0.85	1.62	1.00	0.20	2.93	0.56	15.34
Pensioner	1	-	-	-	-	-	-	-
Retired	-3.09	1.39	4.94	1.00	0.03	0.05	0.001	0.70
Employed	-6.71	4.82	1.94	1.00	0.16	0.001	0.0001	15.53

Discussion

This study aimed to investigate the effect of sociodemographic and health indices on cancer survival among the Iranian MC. Our results showed that the median survival time among all cancer patients was 8.37 years (95% CI: 8.02–8.71) (Figure 1). This result was higher than that of Lin et al. (1.7 years) in US military patients,[11] Brzezniak et al. (1.2 years) in US military lung cancer patients,[12] Mette et al. (4.7 years)—which examined 13 cancers,[13] Ssentongo et al. (5-year survival: 52.8%) in the systematic review of Africa,[14] Moth et al. (1.5 years) in adults with advanced cancer,[15] or Gholizadeh et al. (5-year survival: 47.3%) in patients with larynges cancer in Iran.[16] The results were consistent with that of Kongsiang et al. (8.37 years) in patients with breast cancer.[17] These differences may be due to age or more advanced disease. Previous studies have shown that cancer patients' survival rate has been on the rise in recent years.[18, 19]

Our findings showed that increasing one year in the age of participants adjusted for gender and job status has significantly increased (HR=1.08, 95% CI: 1.03–1.14, P<0.001) the hazard ratio of cancer death (Table 2). The previous study's result was consistent with our findings.[16, 19-21] Age may affect survival in older patients with a higher prevalence of comorbidities compared to younger patients.[22, 23] Also, it is a well-known occurrence that medical treatment was incomplete or substandard, usually in the elderly population, especially in oncology fields.[24] Multiple studies have shown that patients with older age receive less treatment or even no treatment compared to younger patients with a similar diagnosis.[25-27]

Furthermore, our result showed that gender (female) has a significant association with death (HR=0.54, 95% CI: 0.51–0.56, P<0.001). Most studies in the various type of cancer were consistent with our findings.[20, 21] However, some studies could not find an association between gender and cancer death.[16]

In interpreting this association, we should pay attention to the fact that in Iran, as in other countries, females have a higher life expectancy than males [28]. However, if it is advanced stage cancer, there would be no need to consider life expectancy. Nevertheless, cancer was similarly curable for both genders, and survival after treatment would depend on the life expectancy, [29] which would be longer for women in Iran. Our study also showed that HR of death adjusted for age and gender in retired and employed patients was HR=0.05 (95% CI: 0.001-0.7, p=0.03) and HR=0.001 (95% CI: 0.0001-15.53, p=0.16), respectively in comparison with the pensioner. The lower survival rate in the pensioner group can be due to older age and other comorbidities. Since in the health centres, diagnostic tests are performed to detect the patients in the early stage of disease in high-risk individuals (secondary prevention). Survival was expected to be higher in areas with higher numbers of health centres. However, this relationship was not seen in our study (HR=0.49, 95% CI: 0.11–2.16, P=0.35 urban health centres) (HR: 0.34, 95% CI: 0.04–2.9, P=0.32 rural health centres) (Table 2). This may be because, among the participants in this study, the variance of the coverage of health networks is not different among the different provinces.

Furthermore, most cancers require hospital care. Previous studies have shown an association between hospital care and survival in cancer patients.[30] However, this study did not find a significant relationship between hospital variables (such as the number of hospital beds, etc.) and survival rate. This may be due to patients in deprived locations are referred to a better-equipped hospital for treatment, and the quality of services provided to patients had slight variance.

The current study had some limitations, including, first, we didn't have more information about the clinical stage of cancer and other clinical data. Second, the exact time of death in the patient was not known, so we used the date of cancellation of the insurance booklet. Despite the mentioned limitations, the study has very strong components, including the large sample size. Hence, the reproducibility of the results is acceptable, as is the design of the study. Also, the use of registry data increases the generalisability of the findings to the population.

Conclusion

It seems that the access to health services among the Iranian MC in all provinces is the same, and the inequality is few. Except for access to health services, improving lifestyle, reducing environmental pollutant exposure, decreasing anxiety levels, increasing people's awareness of cancer, and the benefits of early detection (primary prevention), can reduce morbidity and mortality of cancers among the Iranian MC.

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Acute Respiratory Epidemics in Australian Military Forces 1940

G. D Shanks, N Marsh

Abstract

Acute respiratory infections due to a variety of viral pathogens can incapacitate entire military units. During World War II, recruit camp epidemics of respiratory infections at Woodside Camp South Australia and Puckapunyal Victoria caused considerable morbidity with up to 44% attack rates but little if any mortality. Camp hospitals were filled with hundreds of recruits in 1940. An infantry battalion (2/9 BN AIF) experienced an epidemic of respiratory disease during its transit from the UK to Suez, Egypt, on a troopship. Although there were no deaths, 30% of the battalion became suddenly ill, and 17% were hospitalised over a single week in December 1940. COVID-19 has drawn modern attention to the casualty-producing potential of epidemic respiratory infections in military units, especially those crowded together for training or during transit to operational areas.

> *'Hospital facilities broke down and sleeping huts within the unit were turned into temporary wards with Australian Imperial Force nurses and members of voluntary Aid Detachments in charge.'*
> CAPT S L Seymour 1941[1]

Acute respiratory diseases are one of the few infectious diseases that can rapidly incapacitate an entire military unit. Although influenza is typically most associated with military operations following the lethal 1918–20 pandemic, other respiratory viruses, such as adenovirus, rhinovirus and coronavirus, are also of great military interest.[2,3] The advent of COVID-19 has particularly focused the minds of military planners on military unit's vulnerability, especially those deployed globally, to respiratory viruses other than influenza.[4] We review the Australian Imperial Force (AIF) experience with acute respiratory infections (ARI) during 1940 as a historical example of what is possible when a new respiratory virus moves into a non-immune population of otherwise healthy soldiers. Although 80 years in the past, the basic biology of exposure and infection has not changed and today's Australian Defence Force (ADF) remains vulnerable to disruptions from new respiratory viruses.

Typically ARIs have been the greatest problem of military recruit camps during mobilisations when large groups of civilians from diverse backgrounds and locations gather together for initial military training.[5] Such was the case at the beginning of World War II when in 1940, a series of ARI epidemics were described in the AIF. These were variably named 'Woodside throat' in South Australia, 'Ingleburn cough' in New South Wales or 'dog's disease' (presumably due to a barking cough).[1] In May 1940, Seymour reported that 400 (44%) of 900 men in a training battalion in Victoria became ill in a single month. Up to 200 were in the hospital or incapacitated in barracks at one time (see the introductory quote to this article).[1] The epidemic was over within another month but not before massive disruptions of training schedules. Illnesses during the epidemic were characterised as pharyngitis, 'burning fire in the throat' and 'as if the head was going to be lifted off' from coughing. Many soldiers were acutely ill, but there were few if any secondary pneumonia cases, as is common with influenza. The illness was rapid with elevated fever for 2–3 days before passing suddenly. There was little nasal discharge at first but became more profuse with nasal obstruction over time.[1] This epidemic occurred at the dawn of virology, and Burnett was eventually able to isolate influenza in eggs during subsequent epidemics in 1941–42.[6,7] The consequences were serious enough for the war effort to initiate a major medical research program at the University of Melbourne, eventually leading to an attenuated, live influenza vaccine. Although one cannot know the viral pathogen involved in 1940, it was unlikely to have been influenza. A possible cause was adenovirus, notable for causing large outbreaks of influenza-like illnesses in military recruit camps.[2]

Late in 1940, a troopship epidemic occurred within the 2/9 Infantry Battalion AIF while en route between the UK and the Middle East. The troopship HMT L13 (SS Dunera) was forced to travel via South Africa

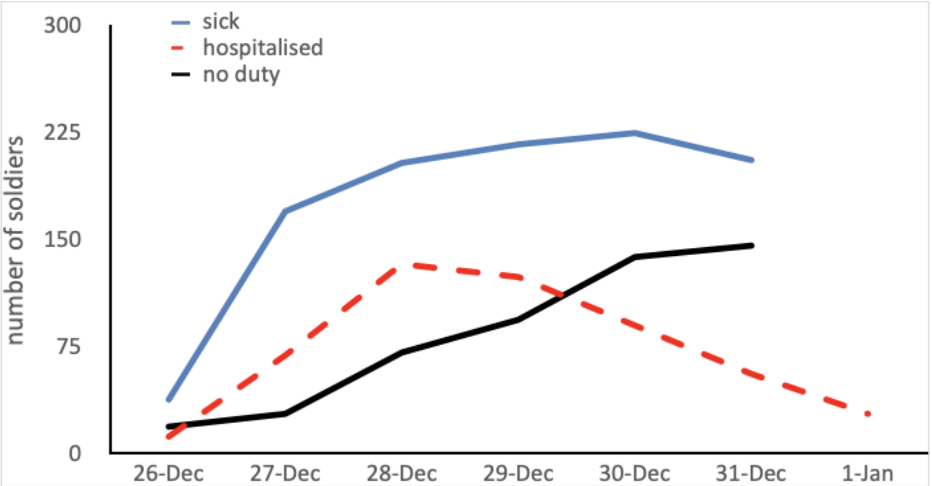

Figure 1: Acute respiratory infection epidemic in the 2/9 BN AIF in December 1940 while onboard the troopship HMT L13 (SS Dunera) while transiting from Durban, South Africa to Suez, Egypt.8

because of war in the Mediterranean. After a 14-week voyage between Durban, South Africa (16 Dec) and Suez, Egypt (28 Dec), 224 of the 738 (30%) soldiers developed ARI over a single week[8] (see Figures 1 and 2). No cases of pneumonia were reported from illnesses that were generally characterised as 'coryza'. Officers and enlisted ranks were equally affected, and most were in the ship's hospital for only 2–3 days. By the time the ship arrived in Alexandria, Egypt (31 Dec), there were still 28 men who had to be transferred to 8th Australian General Hospital. After 10 days, eight of these men re-joined the unit in the desert, indicating that in some cases, the illness continued over more than a week.[8] Nonetheless, the unit had continued to function as the enforced convalescence largely occurred on the ship prior to deployment in Egypt.

Troopships are inherently risky environments for ARI due to the high concentration of soldiers/sailors within limited ventilation areas. The 2/9 BN AIF escaped relatively lightly and continued its deployment to Egypt in January 1941. Classic examples of 'death ships' occurred as recently as World War I when troopships were infected during the 1918 influenza pandemic. HMNZT Tahiti was transporting the 40th Infantry Battalion of the New Zealand Expeditionary Force in August 1918 and experienced 7% overall mortality and 67% morbidity after influenza came aboard in Freetown, Sierra Leone.[9] The 40th BN was immediately placed in quarantine on arrival in the UK and was never able to reconstitute itself into a fighting force before the armistice three months later. Lest one thinks these events are only of historical interest, the US Navy aircraft carrier USS Roosevelt was incapacitated in 2020 by a ship-board epidemic of SARS-CoV2 (COVID-19). The vessel became immobilised in Guam for two months, and a series of crew diagnostic screens eventually found more than 1000 sailors (20% of crew) infected.[10] One death

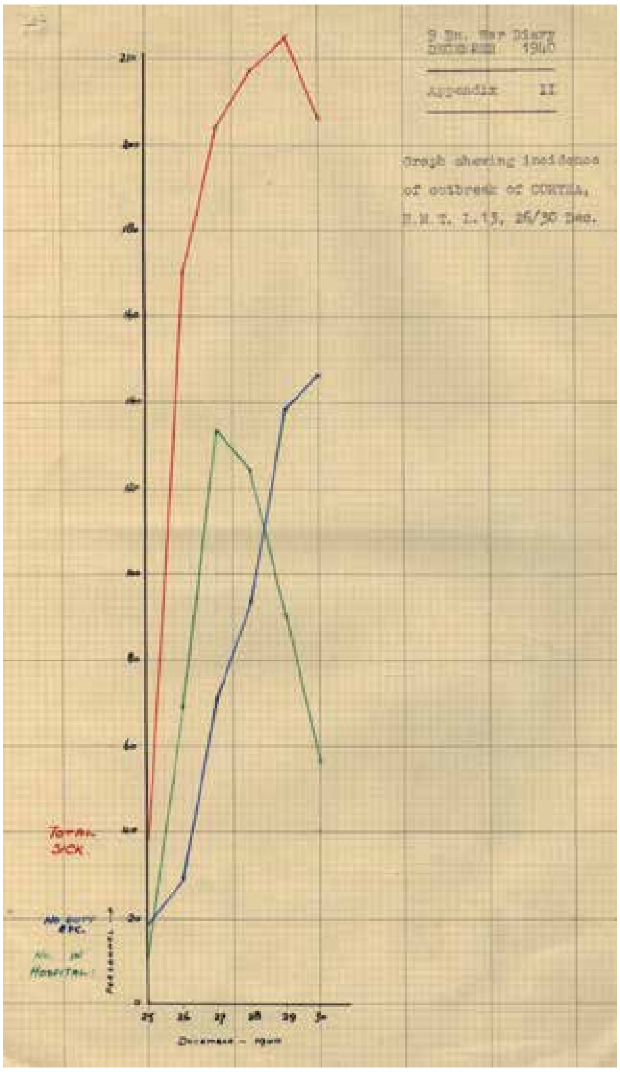

Figure 2: Original data from the same epidemic as it appeared in the Unit War Diary of the 2/9 BN AIF for October-December 1940 from the Australian War Memorial Collection https://s3-ap-southeast-2.amazonaws.com/awm-media/collection/RCDIG1023070/bundled/RCDIG1023070.pdf 8

Supplemental figure: Photo of troopship HMT L13 (SS Dunera) AWM 303219 in the public domain.

resulted from COVID-19, but the important military outcome was no active US Navy carrier battle group in the Western Pacific for a time. This was due to the incapacitation of the USS Roosevelt and to the quarantine of potential replacement units. Despite strenuous efforts using non-pharmacological public health interventions, military deployments involve large numbers of personnel where social distancing is impossible and irreducible risks of ARI epidemics remain.

80 years after the 1940 epidemics, recruit camp and troopship epidemics are no longer common occurrences. This is largely because of the ADF size and because its overseas deployment are usually carried out by aircraft.[9] However, influenza outbreaks often isolate entire training companies at Puckapunyal for weeks, and ARI infections following international flights are common. ARI are ubiquitous infections caused by a wide variety of viral pathogens against which we have both imperfect public health procedures and few vaccines. In our globalised world, newly evolved viruses can disseminate rapidly and, as COVID-19 has rudely reminded us, cause severe human and economic damage. Today, ADF soldiers are much more likely to see mass mortality in aged care facilities in Victoria, Australia, from COVID-19 than on the battlefield from artillery fire. Part of the ADF's adaptation to an uncertain future needs to come from learning from its rich history.[5] ARI is part of the ADF's military experience that previous generations have learnt to manage with practical public health measures aided by new vaccines, which have been the product of targeted medical research. We must aspire to do the same in our current situation.

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Disclaimer:

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Pre-hospital Antibiotics in the Australian Defence Force

C White, M Reade

Abstract

Many militaries around the world use oral and/or parenteral antibiotics in the pre-hospital environment. This narrative literature review investigated the potential use of pre-hospital antibiotics in the ADF by searching several electronic databases for primary evidence from comparative studies of both prospective and retrospective design. There are concerns that the use of pre-hospital antibiotics may increase individual and population bacterial resistance, impede other pre-hospital tasks and increase the risk of *Clostridium difficile* and anaphylaxis. Opposing this, there is a known relationship between delay in the administration of antibiotics and mortality due to sepsis; however, the timeline of when antibiotics are required is not concrete. In contrast, there is a known relationship between delay in antibiotic administration and wound infection for penetrating trauma, advocating for pre-hospital antibiotics for penetrating trauma. The use of oral and parenteral antibiotics, such as clindamycin and cefazolin, administered by medical technicians, would benefit individuals with penetrating wounds, and its implementation into the ADF standard practice should be considered.

Key Words: Pre-hospital; Antibiotics; Military medicine; Penetrating wounds; Sepsis

Introduction

Historically, pre-hospital antibiotics have been widely administered, with the use of topical sulphonamide antibiotics common during World War II.[1] Changing wounding profiles with the increase in blast injuries and concomitant wound contamination together with improved protection leading to increased survival means that post-injury infections are of increasing importance.[2] It is estimated at least a third of all combat casualties will develop infections during their initial hospitalisation.[3] In an attempt to combat this, several countries, including the United States of America (USA) and Israel, have developed protocols for pre-hospital antibiotic use. Thus far, this practice has not been adopted by the Australian Defence Force (ADF).

This paper aims to investigate the potential use of pre-hospital antibiotics within the ADF. There are two distinct scenarios in which pre-hospital antibiotics are likely to be administered: sepsis and penetrating/open wounds. This paper intends to detail the benefits and risks of adopting pre-hospital antibiotics into the clinical care continuum and make recommendations on the most appropriate medication.

Methods

The literature review had no language or chronological restrictions with the following electronic databases searched: PubMed/Medline, EMBASE, Cochrane Central Register of Controlled Trials and clinicaltrials.gov. A customised search strategy was built around the MeSH terms and keywords for pre-hospital, antibiotics, sepsis and penetrating wounds. An internet search using the 'Google Scholar' search engine with the terms 'sepsis, 'penetrating wounds' and 'pre-hospital antibiotics' was also undertaken. Reference lists from full-text articles identified were hand searched for any additional references relevant to the review question.

Pre-hospital antibiotics for sepsis

The Surviving Sepsis Campaign recommends the administration of empirical antibiotics within one hour for septic patients.[4, 5] Time to antibiotics has been widely studied in regards to sepsis; however, primarily within the hospital setting. A number of studies, including populations with 20–47% mortality, noted delayed antibiotic administration was associated with increased mortality.[6–13] Kumar et al. noted in patients with septic shock that each hour of delay in antibiotic administration over the six hours following the onset of hypotension was associated with an average decrease in survival of 7.6%.[6] Studies have demonstrated adverse effects on length of stay,[14] acute kidney injury,[15] and acute lung injury[16] with delayed antibiotics in septic patients.

In a meta-analysis of 16 178 patients across 11 studies, Sterling et al. noted a mortality pooled odds ratio (OR) for patients who received antibiotics three or more hours after triage was 1.16 (95% confidence interval [95% CI] 0.92–1.46; *P*=0.21) compared to those receiving antibiotics within three hours of triage.[17] Authors have argued that most studies within the meta-analyses had significant limitations, including small sample size, arbitrary initial index time point (e.g. emergency department [ED] triage or initial blood culture draw), and indexing of outcome to delay to first antibiotic rather than first appropriate antibiotic.[18] Sterling et al. noted in response, the study was intended to evaluate the role of time to antibiotics as a marker of quality of care rather than the impact of time to effective antibiotics on outcomes.[19]

Since the publication of Sterling et al.'s meta-analysis, Seymour et al. has published two large cohort studies.[12, 13] The first studied 49 331 patients with sepsis or septic shock across 149 hospitals, with longer time to antibiotics (OR 1.04 per hour; 95% CI 1.03–1.06; *P*<0.001) associated with higher risk-adjusted in-hospital mortality.[12] Patients who received antibiotics 3–12 hours post-sepsis protocol activation had 14% higher odds of in-hospital death than those who received antibiotics within three hours (OR 1.14; 95% CI 1.06–1.22; *P*=0.001). This was replicated in a retrospective study of 35 000 randomly selected ED inpatients in Northern California.[20] The second Seymour et al. study of 2683 patients with community-acquired sepsis used various start points to evaluate the effect of antibiotic delay, e.g. time from 911 call, time from paramedic arrival and time from ED arrival.[13] Multivariate analysis found the delay in antibiotic administration from paramedic arrival was associated with increased in-hospital mortality (adjusted mortality OR 1.03 [95% CI 1.00–1.05] per 1-hr delay; *P*<0.01).

The benefits of pre-hospital antibiotics for sepsis may depend on patient population. De Groot et al. noted in a prospective multicentre study based in Dutch EDs that there was no overall association between time to antibiotics and surviving days outside the hospital or mortality.[21] Among individuals with less severe sepsis, there was a paradoxically significant increase in surviving days outside the hospital at day 28 associated with delayed (>3 hours) antibiotic administration and attributed to the effect of residual confounding not accounted for in multivariable adjustment for illness severity. The confounding effect of antibiotic indication, in which the most unwell patients receive earlier treatment but conversely those with occult infection (and hence worse prognosis) might have antibiotic treatment delayed, plagues all observational studies of this question.

A more recent study retrospectively reviewed 308 patients with septic shock treated by a French Mobile Intensive Care Unit, with 98 (32%) receiving predominantly third generation cephalosporins (cefotaxime (47; 67%) or ceftriaxone (27; 36%)).[22] The study found a significant association between pre-hospital antibiotic therapy and 30-day mortality with an adjusted hazard ratio of 0.56 (95% CI 0.35–0.90; *P*=0.01). Individuals who received pre-hospital antibiotics also had shorter hospital stays (7 vs 17 days; *P*<0.001). This was despite individuals receiving pre-hospital antibiotics having a higher mean age (71 vs 69 years; *P*=0.001), mean lactate (5.1 ± 3.8 vs 5.9 ± 3.2 mmol/L; *P*=0.008), SAPS2 score (51 ± 24 vs 53 ± 30; *P*<0.001), and a greater proportion of individuals with chronic cardiac (43% vs 7%; *P*=0.006) and renal failure (29% vs 5%; *P*=0.027). Statistically significant differences were also noted in SOFA scores and Glasgow Coma Scale scores, although the clinical significance is doubtful. Randomised controlled trials (RCTs) are the only method to minimise the effect of both observed and potentially unobserved confounding, which makes them superior to observational study designs. Randomising to delay in appropriate antibiotics would be an unethical and spurious question. That being so, as pre-hospital antibiotics are not standard care and might be associated with risk as well as benefit, there could be equipoise to conduct a trial of this question. An early small RCT randomised 198 patients with septic shock to pre-hospital broad-spectrum intravenous antimicrobial therapy and intravenous fluid therapy or intravenous fluid only.[23] There was a significantly shorter mean intensive care unit (ICU) stay in the pre-hospital antibiotic cohort (6.8 ± 2.1 days vs 11.2 ± 5.2 days; *P*=0.001). The 28-day mortality rate was also significantly reduced with the pre-hospital antibiotic cohort (42.4% vs 56.7%; *P*=0.049; OR = 0.56; 95% CI 0.32–1.00). These results should be interpreted with caution as this data, to date, has only been presented in conference abstract form.

In contrast, the PHANTASi Trial evaluated the use of pre-hospital antibiotics for sepsis in 2672 patients, of whom 1535 received antibiotics a median of 26 minutes (Inter-Quartile Range [IQR] 19–34 minutes) prior to arriving at the ED.[24] Those in the control group had a median time to antibiotics of 70 minutes (IQR 36–128 minutes) after ED arrival. Of note, 99% of those administered pre-hospital antibiotics had blood cultures prior to antibiotic administration. This is important in that it allows the targeting of step-down antibiotics with narrowing of the antibiotic spectrum in hospital care. There were no significant differences in ICU admissions, length of ICU stay, length of hospital stay, 28-day mortality and 90-day mortality between those who did and did not receive pre-hospital antibiotics. Patients given pre-hospital antibiotics had a significantly lower proportion of 28-day re-admissions (7% vs 10%; P=0.0004). The PHANTASi cohort was relatively clinically well, with only 3–4% having septic shock and approximately 10% of patients requiring ICU admission. The power analysis assumed a 40% baseline mortality rate for sepsis, which the PHANTASi authors based on ICU studies of patients with severe sepsis and septic shock. This was considerably higher than the 7.97% (213 deaths in 2672 patients) 28-day mortality rate in the PHANTASi cohort, which suggests the study might be underpowered to find a 28-day mortality difference. Even among those with septic shock, mortality was 28.15% (29 deaths in 103 patients). Consequently, the study's failure to observe effects in the most important outcomes might have been because the patients included were not unwell enough to benefit.

Another potential cause for the lack of difference in mortality among patients with severe sepsis and/or septic shock in the PHANTASi Trial was that the difference in time to antibiotics may not be as profound among sicker patients. Sicker patients may have been transported to hospital more expeditiously and may be assessed and treated quicker within the ED, thus minimising the difference between the two groups. The PHANTASi trail authors note (in the Netherlands) that response times and arrival to ED times are relatively short. Therefore, it would be reasonable to assume that sicker patients would receive more expeditious treatment and potential smaller study arm time differences.

Other issues noted with the PHANTASi study include that general practitioners had referred 73% of patients, and 22% were already on oral antibiotics. It is unclear what this may mean, but it is at variance to the military context where the pre-hospital team is often proximal to the point of injury and the first form of medical care that a patient receives. Additionally, the study was conducted in the Netherlands, which is relatively geographically compact in contrast to the military and Australian context, where there may be considerable distances and/or time to medical care. There was also a difference in the proportion of individuals receiving pre-hospital intravenous fluids, with 64% of the intervention and 37% of the control group receiving pre-hospital intravenous fluids. This probably reflects the intravenous access obtained to allow administration of intravenous antibiotics in the intervention cohort.

In summary, it can be seen that the evidence for pre-hospital antibiotics for septic patients while supportive is by no means definitive. This is not entirely unexpected given the disparate causes and complex heterogeneity of sepsis and the potential for different types of sepsis to behave differently. Further, the military pre-hospital environment is profoundly different from that of the civilian, which must be considered in future studies. There are several pre-hospital trials currently occurring, and this should provide further clarity.

Pre-hospital antibiotics for penetrating wounds

It is common civilian practice to administer antibiotic prophylaxis to patients with open fractures. The Gustillo classification is used to grade soft-tissue injury associated with open fractures. Gustillo Grade I and II injuries (wounds less than 10 cm in size, no more than moderate contamination, and no periosteal stripping) are usually treated with a first-generation cephalosporin (such as cephazolin) until 24 hours after wound closure.[25] Grade III wounds are, at times, additionally treated with an aminoglycoside, fluoroquinolone, third–fourth-generation cephalosporin or penicillin, depending on potential contamination. Several studies have demonstrated that the earlier antibiotics are administered for open fractures, the better the individual's outcomes.[26–28] Preclinical animal models have demonstrated reduced wound colonisation, infection rates and osteomyelitis with antibiotic administration closer to time of injury.[29–37] For penetrating abdominal trauma, prophylactic antibiotics are widely utilised and recommended,[38] and several RCT meta-analyses demonstrate the utility of prophylactic antibiotics for penetrating thoracic wounds.[39, 40] In 1972, Fullen et al. noted a 7–11% post-surgical infection rate with preoperative antibiotics, a 33–57% infection rate with intraoperative antibiotic administration and a 30–70% infection rate with only post-operative antibiotic administration.[41]

In the civilian pre-hospital arena, Thomas et al. prospectively evaluated pre-hospital antibiotics for open fractures in 138 consecutive trauma cases transported by eight US helicopter-based emergency medicine service programs.[42] The time from injury to antibiotics was 30 minutes shorter (47 minutes vs 77 minutes; P<0.0001) when pre-hospital antibiotics were administered. There was no statistical difference between pre-hospital and hospital antibiotic administration for a composite endpoint (infection/non-union). However, this was likely due to the small sample size with only one adverse outcome in the pre-hospital antibiotic cohort.

Evidence from military studies using hospital-based cohorts suggests that early antibiotic administration for open combat wounds reduces infection rates. During the Falklands Islands Campaign, it was noted that no septic complications occurred in soft-tissue extremity injuries when antibiotics were administered within three hours of injury.[43] Gerhardt et al. studied 53 patients injured in Central Iraq, with 43 (81%) receiving systemic antibiotic prophylaxis.[44] Despite no difference in wound mechanisms and anatomical locations, those with antibiotics were significantly less likely to develop an infection within 48 hours (7% vs 40%; OR 0.11 [95% CI 0.02–0.57]), with a number needed to prevent infection within 48 hours of three (95% CI 2–14).

Studies of pre-hospital antibiotic use in the military environment and its effects on open combat wounds are limited. Early studies with narrow population sizes noted no benefit in preventing infectious complications between those receiving and not receiving pre-hospital antibiotics.[45, 46] The most comprehensive study reviewed the US Department of Defense Trauma Registry from January 2007 to August 2016 and identified 15 114 individuals with gunshot wounds (GSWs), traumatic amputations or open-fractures proximal to the digits.[47] No difference in survival until discharge between those receiving and not receiving pre-hospital antibiotics was noted among patients with amputations (93.9% vs 90.7%, P=0.271) or open fractures (96.8% vs 95.9%, P=0.368). Among patients with GSWs there was a significantly higher survival rate among those receiving pre-hospital antibiotics (96.2% vs 92.8%, P<0.001), which persisted in multivariable regression analysis (OR 1.61; 95% CI 1.09–2.38).

Taken together the general consensus is that for traumatic penetrating wounds there is a reasonable body of evidence that early and pre-hospital antibiotics reduce morbidity and mortality. In particular short course and single agent regimens have a role in preventing adverse outcomes in open fractures (25).

Risks of pre-hospital antibiotic use

The addition of any intervention brings with it the potential for additional risks to the patient. In the case of pre-hospital antibiotics, it could include allergic or adverse drug reactions, increased antibiotic resistance and inappropriate antibiotic use.

Anaphylaxis and adverse drug reactions

With the more widespread use of any therapeutic agent, there is the risk of inducing allergic reactions to the agent in question. There is also the risk of other adverse drug reactions, which was demonstrated by the replacement of gatifloxacin with moxifloxacin in the Tactical Care of the Combat Casualty (TCCC) algorithm due to concerns associated with dysglycaemia. Further, there is the risk of the development of other adverse effects, including Clostridium difficle infections. Within the Australian population, fatal anaphylaxis is a rare, albeit devastating, occurrence.[48] Anaphylaxis to beta-lactam antibiotics occurs in approximately 0.001% of parenteral exposures and 0.0005% of oral exposures,[49, 50] with penicillin anaphylaxis appearing to be declining in frequency.[51] Evidence from the use of a single dose of prophylactic antibiotics prior to dental surgery for patients at risk of infective endocarditis has identified a crude anaphylaxis rate of one in 56 878 dental procedures with single-dose amoxicillin prophylaxis.[52] That being so, no fatal anaphylaxis cases were reported.

There were no serious adverse events in those receiving ceftriaxone, such as anaphylactic shock, in the PHANTASi Trial of pre-hospital antibiotics for sepsis.[24] Seven mild allergic reactions occurred, but none were attributed to ceftriaxone. In a cohort of 70 individuals with open wounds with a potential underlying fracture, Lack et al. identified eight individuals (11.43%) with a penicillin allergy who were excluded from receiving intravenous cefazolin.[53] Three patients were identified to have antibiotic allergies (unknown which antibiotic) during their hospital stay, although all three had received 1–2 grams of intravenous cefazolin pre-hospital, without an adverse event.

Inappropriate antibiotic use

Pre-hospital antibiotic use is constrained by logistics that limit the choices available. This has significant potential implications with survival and morbidity benefits only likely to occur when appropriate pre-hospital antibiotics are given. This can be seen in part by the disparate literature surrounding empirical antibiotic use in sepsis.

There is a risk that using an inappropriate antibiotic in the pre-hospital environment may delay appropriate antibiotic treatment. This is not without consequences; Vazquez-Guillamet et al. demonstrated that among septic ED patients, there was a significant increase in mortality when the initial antibiotic chosen was inappropriate (20.5% vs 47.5%; P< 0.001 OR 3.4 [95% CI 2.8–4.1]). This has been reflected in other studies.[54, 55] This can be mitigated by careful selection of the pre-hospital antibiotic to the operating environment and injuries expected to be encountered. There will also typically be a change from the pre-hospital to hospital antibiotic. For example, in the PHANTASi Trial, most patients were continued on amoxicillin-clavulanic acid or ciprofloxacin, not ceftriaxone, when they reached hospital.[24] This mimics standard practice with the switch from parenteral to oral antibiotics and broad to narrow-spectrum antibiotics when the clinical picture becomes clearer.

There are also potential issues with adherence to antibiotic guidelines, particularly in the dynamic tactical pre-hospital environment. This is not unexpected as even in the relatively controlled operating theatre environment, approximately 7% of individuals with orthopaedic trauma do not receive appropriate preoperative antibiotics.[56] Lloyd et al. evaluated receipt of recommended antimicrobials within 48 hours of injury in 1106 military personnel, finding 74% received antimicrobial prophylaxis within 48 hours of injury.[57] Of note, the proportion receiving prophylaxis meeting the guidelines varied from 35–80% depending on the injury. Similar findings were noted by Tribble et al. in a cohort of trauma admissions to Landstuhl Regional Medical Centre, with 75% of trauma patients receiving antibiotic prophylaxis.[58]

Focusing on the pre-hospital environment, Naylor et al., on review of the US Department of Defence Trauma Register from January 2007 to August 2016, noted the proportion of individuals with combat wounds receiving pre-hospital antibiotic prophylaxis was as low as 9.8%.[47] Schauer et al. noted among 50 individuals wounded in Afghanistan, 54% were administered antibiotics, although only 11.1% of the antibiotics were within TCCC guidelines.[59] This has been reflected by some,[46] although others have noted greater compliance with guidelines, albeit with lower proportions of individuals receiving antibiotics.[60] Of note, Schauer et al. found that most individuals seen by a medical officer received antibiotics (73.4%) although only 2.4% of those antibiotics were within the TCCC guidelines.[59] In contrast, 20.7% of individuals seen by a medical technician received antibiotics; however, there was a greater (68.6%) concordance with guidelines. Among other populations, higher proportions of patients were noted to have pre-hospital antibiotic prophylaxis; Naylor et al. noting 80% of paediatric trauma patients admitted to Role Three or Forward Surgical Team facilities had received pre-hospital antibiotics.[61]

Interference with pre-hospital care

Other emergency interventions are also often required in the dynamic pre-hospital environment,[60, 62] which can supersede antibiotic administration. The impetus to administer antibiotics may displace or delay some of these interventions, which may be inappropriate. Among those not receiving pre-hospital antibiotics, Benov et al. found there were a greater number of lifesaving interventions required, more hostile battlefield environments and longer evacuation distances.[60] Others have also noted greater composite Injury Severity Scores among those not receiving pre-hospital antibiotics.[47] Interestingly, civilian studies have noted that longer evacuation times (greater than 30 minutes) increased the chance of receiving pre-hospital antibiotics (29.1% vs 65.8%; *P*<0.001).[53]

Microbial resistance

Increasing antibiotic use is widely accepted to be a key contributor to the development of antibiotic resistance. Khalil et al. demonstrated that a single 2 gram amoxicillin dose can significantly alter the oral microbiome and induce a significant selection of resistant microorganisms.[63] Studies have also demonstrated increased microbial resistance following antibiotic exposure and increased resistance with increased antibiotic consumption.[64–68] Lloyd et al. reviewed individuals with open extremity soft-tissue injuries or open fractures sustained in Iraq and Afghanistan (2009–2014) that required transfer to USA hospitals.[69, 70] A higher proportion of fluoroquinolone and/or aminoglycoside resistant gram-negative organisms were found in patients who received expanded gram-negative antibiotic coverage (Soft-tissue injuries 35% vs 19%, p < 0.001; open fractures 49% vs 40%, *P*<0.001).

There is minimal data regarding the effect of pre-hospital antibiotics on microbial resistance, although there are some potential indirect markers. In the PHANTASi Trial, positive urine cultures were less frequent among those given antibiotics prior to hospital arrival (25 [25%] of 1048 vs 295 [37%] of 801; *P*<0·0001), which the authors attributed to pre-hospital antibiotics.[24] More definitively, Murray et al. retrospectively reviewed the outcomes of 211 causalities up to 30 days post-injury, with 28 (13.3%) subsequently found to be infected with gram-negative bacteria with pre-hospital administration of a single-dose broad-spectrum antibiotic not altering infection or colonisation rates.[46]

Antibiotic options

The ideal pre-hospital antibiotic would be well tolerated, stable across a range of environmental conditions, easily administered in a dynamic environment, active against a wide variety of potential microorganisms and have a low risk of adverse effects and microbial resistance induction. Furthermore, the antibiotic would be already available within the ADF formulary or at least within widespread Australian clinical practice.

Pathogens isolated from traumatic war wounds include a mixture of gram-positive and gram-negative organisms, notably Enterococcus species, *Staphylococcus* aureus, *Acinetobacter calcoaceticus–baumannii* complex, *Escherichia coli, Pseudomonas aeruginosa* and *Klebsiella pneumoniae*.[3, 45, 71–76] The microbiology of traumatic wounds vary as casualties pass through the military medical system from the combat theatre, interim facilities, to final medical treatment facilities.[77, 78] In regards to point of injury contamination, Murray et al. cultured 49 US military members with 61 separate traumatic wounds at initial presentation to a combat support hospital in Iraq.[79] Thirty wounds (49%) had positive bacterial cultures, with 40 different bacteria identified. Of note, 18 casualties (20 wounds) had pre-hospital irrigation and/or antibiotic therapy; of these, 6 wounds (30%) had positive cultures with 9 different bacterial isolates. Of the 41 wounds from 31 patients who had received no pre-hospital irrigation/antibiotics, 24 wounds (58%) grew 31 different bacteria. Gram-positive bacteria (93%), mostly skin-commensal bacteria, e.g. coagulase-negative *Staphylococcus* and *Staphylococcus aureus*, were the predominant organisms identified. Only three gram-negative bacteria were detected, none of which were considered to have significant antimicrobial resistance. The only resistant bacteria recovered were two cultures of methicillin-resistant *Staphylococcus aureus*. The authors concluded that the use of broad-spectrum antibiotics with efficacy against more resistant, gram-negative bacteria, e.g. *Pseudomonas aeruginosa* and *Acinetobacter*, is unnecessary in early wound management. This was reinforced by Lloyd et al. who noted in individuals with open extremity fractures that the use of expanded gram-negative coverage (e.g. fluoroquinolones or aminoglycosides) led to a small reduction in soft-tissue and skin infections but did not decrease the risk of osteomyelitis and led to an increase in antibiotic-resistant organisms.70 A further study by Lloyd et al. of individuals with open extremity soft-tissue injuries noted no significant difference between narrow and expanded gram-negative antibiotic regimes in extremity skin and soft-tissue infection, hospitalisation duration, mortality, number of operations and non-extremity infections.[69] Patients that received expanded gram-negative antibiotic regimes were significantly more likely to culture gram-negative organisms resistant to expanded gram-negative antibiotics. Consequently, Lloyd et al. recommended using cefazolin or clindamycin for open fracture wound empirical treatment, which is reflected in the guidelines for the Prevention of Infections Associated with Combat-Related Injuries.[80]

A key consideration in the use of pre-hospital antibiotics is how the antibiotics are administered, namely oral versus parenteral. The oral route can be easily taken at point of injury, particularly if issued to individual service members. Furthermore, there is decreased time and logistic burden of reconstituting and administered parenteral medication when oral medication is used. Oral medications also allow medical personnel to carry multiple doses in a single foil packet. This must be balanced by the potential inability or inadvisability of oral medication in some wounding scenarios. If issued to all personnel, there is also the potential for oral medication to be misused for incorrect indications, thereby delaying appropriate care and leaving the individual without medication when it is required. Taken together, an oral preparation would theoretically increase the likelihood of an injured individual receiving the medication but has the potential for misadministration/use.

Various militaries use a range of pre-hospital or early medical antibiotic options for the treatment of penetrating combat wounds (Table 1). Militaries from the Federal Republic of Germany, the USA and Israel use antibiotics in the pre-hospital environment, while the United Kingdom and France advocate antibiotic prophylaxis upon arrival at medical facilities. The USA and several other militaries use the TCCC guidelines that recommend a combination of oral and parenteral pre-hospital antibiotics for traumatic wounds.

The TCCC program advocates for the Combat Wound Medication Pack (CWMP) that consists of paracetamol, a non-steroidal anti-inflammatory drug and an oral antibiotic. A fourth-generation fluoroquinolone (400 mg moxifloxacin) choice was based on the range of activity against pathogens expected to be encountered in military environments, relatively low side-effect profiles, favourable oral pharmacokinetics and once-daily dosing options.[81] Naylor et al. reviewed the USA Department of Defence Trauma Registry for 11 655 US service members with TCCC indications for CWMP administration between January 2007 and August 2016, finding 84 (0.72%) received pre-hospital oral antibiotics.[82] Recipients of the CWMP were less likely to have an extremity injury, more likely to be in Afghanistan (versus Iraq) and have a lower composite injury score. Other studies of special forces units, namely the 75th Ranger Regiment of the US Army, have noted higher utilisation in the region of 19–21%.[46, 83] A key limiting factor in the use of

Table 1. Military pre-hospital antibiotic recommendations

Country / Organisation	Medication recommendations
United States of America Canada	Oral • 400 mg moxifloxacin OR • 500 mg levofloxacin Parenteral • 1 gm IV/IM ertapenem OR • 2 gm IV/IM cefotetan
Israel Armed Forces	2 gm IV ceftriaxone Abdominal / Head injuries • 2 gm IV ceftriaxone PLUS • 500 mg IV metronidazole
German Armed Forces	Oral • 750 mg ciprofloxacin OR • 500 mg levofloxacin OR • 600 mg clindamycin Parenteral • piperacillin 4 gm + tazobactam 500 mg IV
French Armed Forces	No prehospital guidelines but parenteral prophylaxis on arrival at Medical treatment facility with: 2 gm IV amoxicillin + clavulanic acid OR 600 mg IV clindamycin
United Kingdom Armed Forces	No prehospital guidelines but parenteral prophylaxis on arrival at Medical treatment facility with: Extremity injuries • 1.2 gm IV benzylpenicillin PLUS • 1 gm IV flucloxacillin Hollow viscera injuries • 500 mg IV metronidazole PLUS • 1.5 gm IV cefuroxime

Adapted from (91–94).

CWMP has been postulated to be logistical issues.[84, 85] Consequently, Naylor et al. recommended that for the wider military that CWMP be supplied to medics rather than individuals to minimise some of the issues associated with appropriate administration and logistical supply.

For parenteral pre-hospital antibiotics, TCCC recommends single-dose ertapenem 1 gm IV or IM if penetrating abdominal injury, shock or unable to tolerate PO medications. Recommended alternate agents include cefotetan 2 gm IV or IM 12 hourly or a single dose of levofloxacin 500 mg PO. Schaeur et al. noted no documented cefotetan use in their review of individuals wounded in Afghanistan, despite its recommendation as an alternative agent.[59] They postulated several reasons for this, including lack of awareness, ready ertapenem availability, limited cefotetan availability and higher cefotetan cost.

Moxifloxacin is used to a limited degree in Australian civilian practice, primarily for indications such as community-acquired pneumonia, chronic bronchitis and sinusitis. However, fluoroquinolone resistance has led to recommendations against its use as a first-line agent.[86] Ertapenem is a carbapenem related to meropenem, typically reserved for life-threatening infections due to organisms not susceptible to narrower-spectrum agents. In Australian public hospital practice, its use typically requires specialist infectious diseases physician authorisation based on microbiological cultures.

The International Council of the Red Cross (ICRC) recommends that all patients with penetrating wounds receive five million units of benzylpenicillin IV on admission with alternatives in the case of penicillin allergy being erythromycin, chloramphenicol or a cephalosporin.[87, 88] The use of penicillin is based on the knowledge that '*Streptococcus pyogenes, Clostridium welchii* and *Clostridium tetani* are always sensitive to it'.[87] The ICRC provides further guidance for a number of additional scenarios to substitute or add additional antibiotics (Table 2).[89]

The Primary Clinical Care Manual (PCCM) that governs much of the ADF Medical Technician's practice provides the means for medical technicians

Table 2. International Committee of the Red Cross Antibiotic Prophylaxis Protocol for Adults with Weapon Wounds

Injury	Recommendation
Penetrating craniocerebral wounds	• 2 gm IV ceftriaxone daily for 48 hours
Eye and maxillofacial wounds affecting a cavity (nasal, oral and/or sinus)	• 2 gm IV cefazolin 12 hourly for 48 hours, AND • 500 mg IV metronidazole 8 hourly for 48 hours
Eye and maxillofacial wounds not affecting a cavity (nasal, oral and/or sinus)	• 2 gm IV cefazolin 12 hourly for 48 hours
Surgery or delayed primary closure on minor soft-tissue wounds	• 2 gm IV cefazolin daily for 48 hours
Chest drain placement for haemothorax	• 2 gm IV cefazolin daily for 48 hours
Amputations, open fractures or major soft-tissue wounds	Less than 72 hours from point of injury • 2 gm IV cefazolin 12 hourly for 48 hours Greater than 72 hours from point of injury • 2 gm IV cefazolin 12 hourly for 48 hours AND • 500 mg IV metronidazole 8 hourly for 48 hours AND • 5 mg/kg IV gentamicin daily for 48 hours
Limb injuries from antipersonnel mines	• 2 gm IV cefazolin 12 hourly for 48 hours AND • 500 mg IV metronidazole 8 hourly for 48 hours AND • 5 mg/kg IV gentamicin daily for 48 hours
Abdominal wounds	• 2 gm IV cefazolin 12 hourly for 48 hours AND • 500 mg IV metronidazole 8 hourly for 48 hours AND • 5 mg/kg IV gentamicin daily for 48 hours

Adapted from International Committee of the Red Cross Anaesthesia Handbook (88).

to administer antibiotics under remote supervision of a nursing practitioner or medical officer.[90] For sepsis, the PCCM recommends the administration of gentamicin plus flucloxacillin with the addition of vancomycin for methicillin-resistant Staphylococcus aureus and ceftriaxone for suspected meningitis (Table 3). The PCCM does not provide a specific recommendation for penetrating traumatic wound antibiotic prophylaxis, apart from some situations (Table 4), suggesting the choice is at the supervising medical officer's discretion. The electronic Therapeutic Guidelines (eTG), which guide many medical officers' practice, for the most part, reflect the PCCM, although there are several differences (Table 5).[91]

Potential pre-hospital antibiotic in the Australian Defence Force

The summation of the above would be that there is a reasonable body of evidence that pre-hospital prophylactic antibiotics reduce wound infection and mortality in penetrating trauma without an appreciable incidence of adverse events. There are a number of opportunities within the pre-hospital continuum to administer antibiotics, ranging from individual issue to provision as part of the evacuation process (Figure 1). The choice of antibiotic and administration protocol is likely to influence when pre-hospital antibiotics can be administered.

A cephalosporin would avoid some issues associated with adverse drug reactions to penicillins. It would also concur with established clinical guidelines, with cefazolin widely utilised in the preoperative setting due to its narrow spectrum of action that still covers the bacteria commonly encountered in surgery and post-operative infection for penetrating wounds.[57, 80, 89] Ceftriaxone is already utilised in the PCCM for several clinical indications, including bite wounds, orbital cellulitis, meningitis, sexually transmitted infections, pyelonephritis, urosepsis and epiglottitis.[90] Further, ceftriaxone is used by several Australian ambulance services in the pre-hospital environment. Consequently, ADF medical technicians are likely to have already been exposed

Table 3. Primary Clinical Care Manual Antibiotic Guidelines for Empirical Sepsis and Meningitis Treatment

Empirical sepsis treatment	
Children	
< 2 months	• 50 mg/kg ≤2 gm IV/IM cefotaxime PLUS • 50 mg/kg ≤2 gm IV/IM ampicillin If MRSA risk and > 1 month old ADD 15 mg/kg ≤ 750 mg IV vancomycin
2 months to 16 years	• 50 mg/kg ≤2 gm IV/IM cefotaxime If MRSA risk and > 1 month old ADD 15 mg/kg ≤ 750 mg IV vancomycin

Child with septic shock or critical illness	REPLACE above with:
	• 50 mg/kg ≤2g IV/IM cefotaxime PLUS
	• 15 mg/kg ≤750mg IV vancomycin PLUS
	• IV gentamicin as below:
	  • Term neonates ≤ 1-month 5 mg/kg
	  • 1 month to < 10 years 7.5 mg/kg ≤320 mg
	  • 10 years < 16 years 6 mg/kg ≤560 mg (OR if critically ill/septic shock 7 mg/kg ≤640 mg)

Adults (> 16 years old)	
	• 5 mg/kg IBW/AdjBW ≤500 mg (OR for septic shock 7 mg/kg IBW/AdjBW ≤700 mg) IV gentamicin PLUS • 2 gm IV/IM flucloxacillin If MRSA risk ADD 30 mg/kg ABW loading dose IV vancomycin November–May (tropical wet season) in areas north of Mackay, Tennant Creek and Port Hedland consider 1 gm IV Meropenem and 30 mg/kg IV vancomycin in place of antibiotic regimen above
Additional considerations all ages	
If meningitis cannot be excluded ADD 50 mg/kg ≤2 gm IV/IM ceftriaxone	
Empirical meningitis treatment	
Neonates and infants < 2 months	• 50 mg/kg ≤2 gm IV/IM cefotaxime PLUS • 50 mg/kg ≤2 gm IV/IM ampicillin
Children ≥ 2 months and adults	• 50 mg/kg ≤2 gm IV/IM cefotaxime OR • 50 mg/kg ≤2 gm IV/IM ceftriaxone If critically ill immunocompetent child ≥ 2 months may ADD Gentamicin PLUS Vancomycin as per empirical sepsis dosage If immunocompromised, >50 years old, history of heavy alcohol consumption, pregnant or debilitated ADD 2.4 gm IV/IM benzylpenicillin

Note: IBW: Ideal body weight; ABW: Actual body weight; AdjBW: Adjusted body weight.
Adapted from 10th Edition Primary Clinical Care Manual (89).

Figure 1. Australian Defence Force pre-hospital antibiotic administration points

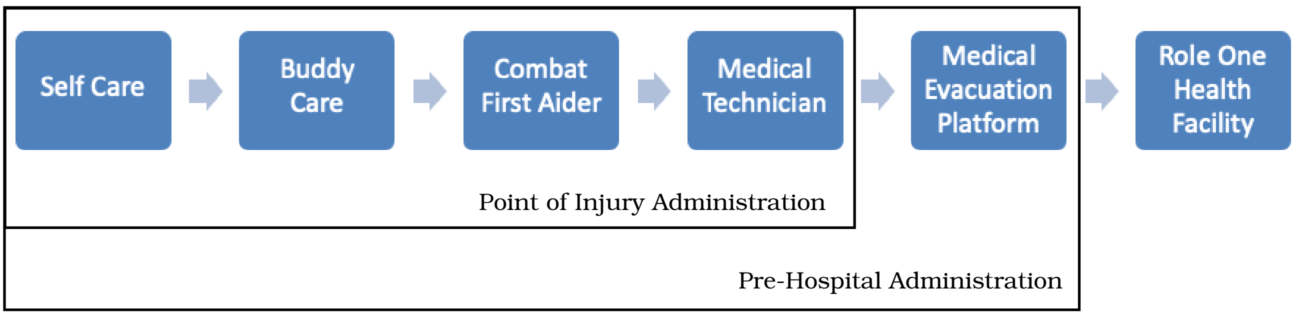

Table 4. Primary Clinical Care Manual Antibiotic Guidelines for Specific Circumstances

Injury	Recommendation
Traumatic jaw injury	• 1200 mg IV benzylpenicillin 6 hourly and 400 mg PO metronidazole 12 hourly OR • 500 mg PO amoxicillin 8 hourly and 400 mg PO metronidazole 12 hourly
Compound or basal skull fracture	As per meningitis pathway detailed in Table 3
Human (tooth-knuckle) and animal bites	875 mg + 125 mg PO amoxicillin + clavulanic acid 12 hourly If lack of adherence is anticipated or delay in commencing oral antibiotics treat with: • 1500 mg IM procaine benzylpenicillin PLUS • 875 mg + 125 mg PO amoxicillin + clavulanic acid 12 hourly if allergic to penicillin, treat with: • 400 mg PO metronidazole 12 hourly PLUS • 200 mg first dose then 100 mg PO doxycycline daily

Adapted from 10th Edition Primary Clinical Care Manual (89).

Table 5. Electronic Therapeutic Guidelines for Antibiotic Prophylaxis

Injury	Recommendation
Open fracture	2 gm IV cefazolin 8 hourly If water immersion substitute cefazolin with: • 2 gm IV cefepime 8 hourly If severe / heavily contaminated: • 2 gm IV cefazolin 8 hourly PLUS • 500 mg IV metronidazole 12 hourly If severe penicillin hypersensitivity and can tolerate oral medication • 450 mg PO clindamycin 8 hourly If water immersion, severe penicillin hypersensitivity and can tolerate oral medication: • 450 mg PO clindamycin 8 hourly PLUS • 750 mg PO ciprofloxacin 12 hourly
Human (tooth-knuckle) and animal bites	875 mg + 125 mg PO amoxicillin + clavulanate 12 hourly for three days If lack of adherence is anticipated or delay in commencing oral antibiotics treat with: • 1500 mg IM procaine benzylpenicillin PLUS • 875 mg + 125 mg PO amoxicillin + clavulanate 12 hourly for three days If unable to tolerate oral mediation • 1000 mg + 200 mg IV amoxicillin + clavulanate 8 hourly If allergic to penicillin, or at increased risk of methicillin-resistant *Staphylococcus aureus* infection: • 400 mg PO metronidazole 12 hourly PLUS • 100 mg PO doxycycline daily for three days OR • 160 mg + 800 mg PO trimethoprim + sulfamethoxazole 12 hourly for three days
Penetrating eye injury	400 mg PO moxifloxacin daily for 5–7 days OR 750 mg PO ciprofloxacin 12 hourly for 5–7 days

Adapted from electronic Therapeutic Guidelines (90).

Table 6. Proposed Australian Defence Force Prehospital Antibiotic Guideline

Situation	Recommendation
Sepsis / Septic shock	Intravenous/intramuscular agent • 2 gm ceftriaxone 12 hourly OR • 2 gm ceftazidime 12 hourly (if melioidosis risk)
Penetrating trauma / Open wound	Oral agent • 450 mg clindamycin 8 hourly Intravenous/intramuscular agent • 2 gm cefazolin 8 hourly

to and administered the medication. Ceftriaxone also has the added benefit of once-daily dosing and being able to be administered by the intravenous and intramuscular route. Consequently, a first-generation cephalosporin, such as 2 gm cefazolin IV/IM 8 hourly, would be recommended for post-traumatic wound prophylaxis (Table 6). For sepsis, a third-generation cephalosporin, such as 2 gm ceftriaxone IV/IM 12 hourly, could recommend for most parts of the world, unless there are local reasons to modify this, e.g. if melioidosis was a substantial risk, 2 gm ceftazidime IV/IM would be a reasonable choice.

Regarding the provision of an oral antibiotic or equivalent to the CWMP to ADF members, the situation is less clear. The US Armed Forces experience has demonstrated a relatively low uptake of the CWMP outside specialised units. Even with uptake, there is still relatively low utilisation of the medication outside special forces units. In their most recent pre-hospital antibiotic guidelines, the Israeli Defence Force removed oral antibiotics from their algorithm.[92] The issues surrounding antibiotic choice and logistic supply are likely to render pre-hospital oral antibiotics an option in development for individual issue. There remains the option to equip appropriately trained medical personal with oral antibiotics to provide to injured service members, which would avoid a number of the associated logistical issues.

The decision regarding the most appropriate oral antibiotic is less clear. As noted in Table 1, other militaries use moxifloxacin, levofloxacin, ciprofloxacin or clindamycin as their oral antibiotics. Fluoroquinolones are not recommended for parenteral early post-traumatic antibiotics; thus, the assumption would be that the expanded spectrum would also not be required for oral pre-hospital medication. Clindamycin is the alternative agent in the German Armed Forces,[93] which concurs with the eTG guidelines for individuals with open fractures and penicillin anaphylaxis.[91] The German Armed Forces recommend a 600 mg dose,[93] while the eTG guidelines recommend 450 mg doses three times a day for open fractures in individuals with penicillin anaphylaxis.[91] Australian blister pack sizes of 24 and 200 tablets are available; thus, a blister pack of 24 tablets would provide eight 450 mg or six 600 mg doses in a relatively small and easily administered package. The avoidance of penicillin allergy risks with clindamycin is also beneficial if individual antibiotics issue is to be considered.

The future

There remain concerns that pre-hospital antibiotics may lead to inappropriate antibiotic choices, increase bacterial resistance in individuals and the population, distract from more useful tasks, and increased risk of adverse drug reactions. Opposing this, there is a known relationship between delay in antibiotic administration and mortality due to sepsis; however, the timeline of when antibiotics are required is not concrete. This suggests that further trials are required for pre-hospital use of antibiotics for sepsis, particularly regarding its applicability to the military context. In contrast, there is a known relationship between delayed antibiotic administration and wound infection for penetrating trauma; advocating for the use of pre-hospital antibiotics for penetrating trauma. Taken together, this would suggest the use of oral and parenteral antibiotics, such as clindamycin and cefazolin, administered by medical technicians would benefit individuals with penetrating wounds and its implementation into the ADF standard of practice should be considered.

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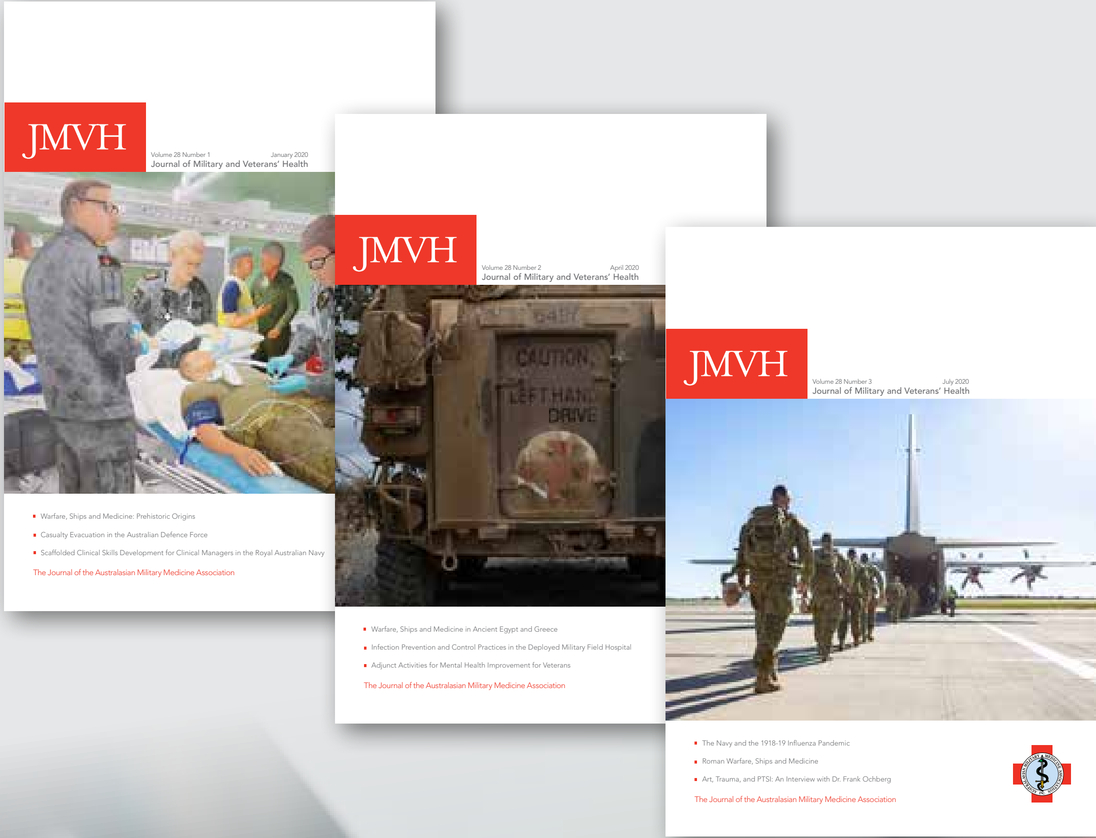

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