



- Melanoma in Aircrew and Defence Force Members: A Narrative Literature Review
- Hearing Health in the Australian Defence Force
- Measuring Dental Fear and Anxiety in New Zealand Defence Force Personnel





## Ask your patients: Have you served in the ADF?

*Ex-serving ADF personnel are different from your other patients. Understanding the veteran experience will make it easier for you to connect.*



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It is recommended that a 45 minute consultation be undertaken for the Veteran Health Check and an assessment tool is available to help you check for health conditions that are common to veterans.

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- psychological distress



There are two ways to access the Veterans' Health Check Assessment Tool:

- Search '**ADF post-discharge GP Health Assessment**' in Best Practice or MedicalDirector
- Download the tool from [www.dva.gov.au/veteranshealthcheckproviders](http://www.dva.gov.au/veteranshealthcheckproviders).

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# Journal of Military and Veterans' Health

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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.

JMVH is published by the  
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# Guest Editorial



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## Common Military Medicine Challenges in an Increasingly Unstable World

The 45th International Congress on Military Medicine (ICMM) was hosted in Brisbane, Australia, from 16 to 20 September 2024. For over 100 years ICMM has provided a neutral forum for now over 100 countries to share medical advances towards a single common aim—to collectively improve the outcomes of our patients. The opening plenary address was delivered by the Committee of Chiefs of Military Medical Services Chair in NATO (colloquially known as ‘COMEDS’), the senior medical adviser position within the NATO security alliance of 32 states. To set the scene for the conference, the theme was the military medicine challenges that all nations face in an increasingly unstable world, taking illustrations from the United Kingdom’s experience and the speaker’s former role as Surgeon General. This editorial is a transcript of the speech delivered by Chair COMEDS.

The start point is the common global context in which we all exist as clinicians within military medicine and to consider our role in three environments—a future pandemic, a natural disaster and war. In the last 20 years, we have experienced a recurring cycle, roughly every 5 years, of a virus spreading internationally in epidemic or pandemic proportions. Most of our countries were incompletely prepared to deal with the scale of seriously ill patients in the COVID-19 pandemic, and many turned to their military health services for support with emergency planning, medical logistics and reinforcement for their overstretched civilian health services. Indeed, how our military health services are viewed within our nations has been reset. It should, therefore, be predictable that in any future epidemic or pandemic, our help will be sought early. But public and corporate memories are short, and it is our duty to sustain this hard-learned lesson from our shared contemporary military history.

The prevalence of natural disasters is increasing. In the 40 years from 1980, the global prevalence has risen almost fourfold. Some countries, particularly those with large standing armies, have integrated their militaries to take a leading role in the rapid humanitarian response. In others, and the UK is an example here, the military is regarded as a ‘last resort’, but when selected, it repeatedly demonstrates its agility, flexibility, self-sufficiency and clinical utility. Whatever the historical national politics, if natural

disasters are set to keep rising, then the logic must surely be to enhance the civil-military collaboration in response to them, using all the available capable assets to full effect in the interest of humanity.

As military clinicians, we experience the appalling human consequences of war. Yet, as military officers, we understand that when our national interests or national security are threatened, and both diplomatic and economic levers of influence have failed, then war becomes a recurring inevitability. Today, I feel the world is more geopolitically unstable than at any time in my 40-year career. We have war on the European continent and the threat of a political miscalculation, which may lead to rapid expansion through invoking NATO Article 5, noting if *any* member state asks for help when attacked, *all* will respond. Indeed, our European leaders have consistently messaged publicly this year that we are 'in a prewar era and must be prepared to fight an increasingly aggressive Russia'. In addition, we have war established in the Middle East for almost one year that shows no sign of imminent resolution, that involves proxy State actors, and that retains the worrying possibility of further regional expansion. And for this part of the world [where ICMM is taking place], where Asian and Australasian security is foremost in your minds, then conflict is threatened through existential tensions in the Korean Peninsula and the South China Sea.

So, what are our shared challenges, and what can we do to mitigate the medical risks that we all collectively hold, with the common aim of improving patient outcomes? This is something that I, and my Surgeon General colleagues in NATO, have given a great deal of thought to. These considerations have, of course, been driven by Russia's invasion of Ukraine and our reflection on NATO's medical capabilities and capacity to deal with enduring large-scale casualties from combat operations. It has resulted in shared medical risks being considered in five broad themes within a *Medical Manifesto* approved by the Heads of State at the Washington Summit in July this year, which I believe is highly transferable to this whole audience. I can, of course, only give you headlines and principles, not any detail, for obvious reasons of security.

The first shared challenge is workforce, and you will all be only too aware of the global healthcare worker shortage. Two solutions present themselves in partial mitigation. One is multinationality, and we know this works. We've been doing this in NATO since the Balkans in the 1990s and again successfully in Iraq and Afghanistan, where we deployed a framework nation hospital supported by individual augmentees

or clinical teams from one or more other nations. It's made easier by training together in advance—but that's not essential. In Mali in 2022, a British surgical team and a Swedish blood bank team reinforced a German Role 1 during a major incident of German casualties without prior exercise or joint training. It worked. A parallel solution is for enhanced civil-military collaboration, and this is at the heart of NATO's *Medical Support Capstone Concept* launched in 2022, and it has driven civil-military integration across the headquarters in the last 2 years, specifically between the military COMEDS committee of surgeon generals and the civilian Joint Health Group of national clinical representatives. Indeed, we have convened combined strategic meetings of civil and military national healthcare leaders to discuss joint plans for large-scale combat operations. Yet, we must be clear that greater civil-military collaboration is *not* a substitute for investment in military people capability.

The second shared challenge is medical logistics and how we sustain support for the treatment of a high volume of casualties. One thing COVID taught us was that our supply chains are vulnerable if every nation is demanding against the same supplier, or we are overly reliant on imports and the supply chain becomes contested. This forces us to consider holding more stock—and as one example, UK Defence has committed the funds to substantially uplift our medical consumable stockpiles while doing this intelligently to limit future waste through discussion with our civilian National Health Service on stock rotation. It is also essential to consider what consumables need to be manufactured in your own country, which is what we call a 'sovereign capability'. Again, one example from the UK is to now manufacture our own freeze-dried plasma, which provides some mitigation to forward provision of blood products in austere environments.

The third substantial challenge is preparedness for mass casualties. Peer-on-peer war will mean a sustained a high number of casualties, necessarily managed by finite medical facilities that will be regularly overwhelmed. The irony has not escaped me that my military medical career started in the Cold War, based in a military hospital in Germany where we were prepared for defence against a Russian invasion. We had an annual exercise to deploy to our field hospital locations, which were predetermined. The infrastructure and equipment were basic and were designed for 'good enough' care for the many in large-scale combat operations, not the exquisite care for low numbers of casualties that has become the expectation from our extraordinary patient outcomes in Iraq and Afghanistan earlier this century.

Today, we do recognise how our proven high clinical capability *but low residual capacity* is a strategic mismatch. It follows the decades of peace dividend in Europe since the end of the Cold War that have resulted in serially smaller standing armies. Yet despite my career being dedicated to driving up clinical standards and improving outcomes from serious injury in *asymmetric* operations, I have the uncomfortable realisation that the basic level of hospital care we were providing in the 1980s was perhaps a more realistic expectation of what can be delivered in peer-on-peer war.

So, we need to think of how we prepare for enduring mass casualties from two aspects. These are our requirements in the home nation and our requirements within any overseas theatre of war. In the home nation, we can refer to our preparedness process as 'RAMP', or *Reception Arrangements for Military Patients*. In the UK, our process has served us well for over 20 years. We have brought nearly all injured and sick Service personnel back to a single hospital in Birmingham, the Royal Centre for Defence Medicine. But this plan won't work for large numbers of patients. It will have to become *scalable* from our historic environment of asymmetric low-intensity conflict all the way through to high-intensity warfighting, which will necessitate national casualty redistribution. And importantly, these medical precepts are being inculcated into a new National Defence Plan.

Of note also is how we prepare our civilian clinical staff who are typically unused to managing blast and ballistic injury, because our civilian hospitals will provide the capacity to receive our military patients. In this respect, the UK has prepared because, in 2017, we published clinical guidelines for all civilian hospitals<sup>1</sup> that were derived from our military guidelines first written in 2003. Our imperative in 2017 was to create effectiveness to deal with casualties of terrorism, but of course, the principles clearly apply to casualties of war. How you create additional rehabilitation capacity to get soldiers back to the fight is another challenge. It is one the UK planned for in 1991 for the first Gulf War when we decided to repurpose existing holiday camp infrastructure.

A good deal of effort has been invested in NATO through the Emergency Medicine Panel to create a series of new precepts for managing an enduring mass casualty challenge, whether at home or on expeditionary operations. This has been Ukraine's experience for two-and-a-half years. In our peacetime civilian experience of a plane crash, a train crash or a terrorist bomb, we have principles to deal with a

casualty surge at a point in time. But what if that surge is an enduring pressure wave? Reassuringly, we now have the '8 Ds' to give a consistent approach in a resource-poor environment, which you can find in Open Access publications.<sup>2</sup>

The fourth challenge is casualty movement capacity both tactical to the first surgical facility and strategic across international borders. Tactical evacuation using protected mobility has been a consistent high priority for support that Ukraine has sought from the international community. We know that clinical outcomes are directly related to the time to surgery, and without timely evacuation, there will be an excess of avoidable deaths that we see expressed in the Killed in Action to Wounded in Action ratio.

When it comes to strategic evacuation between countries, there will be finite military assets, and we will turn to commandeering civilian assets to create the capacity to move by air, sea or rail. For reversionary methods, such as rail and buses, which we effectively used 100 years ago, we must re-learn old lessons and re-invest in the flexibility to use these means. The conversations are certainly being held with relevant national government agencies and at the international level for how we would move patients across the European continent and stage through strategic evacuation hubs from where national teams may retrieve their own patients for the last part of the journey. This process is encapsulated within NATO's *Patient Management Flow Directive*, which has been pressure-tested and refined on serial exercises over the last two years.

The final domain to consider is regulatory constraints, which are a potential fire blanket to interoperability. At the heart of NATO's effectiveness as an alliance is interoperability, with the ability to work together to amplify the medical effect and to burden-share the medical risk. But the clinical professions are heavily regulated and we carry forward national regulations into a deployed multinational environment, where they can create obstacles to this necessary interoperability. Managing this at the tactical or even operational levels creates time-consuming bureaucracy, which is why it is a strategic priority and opportunity to unlock. Yet this is somewhat artificial because doctors will be doctors. If a sick patient of another nation needs blood, they will get blood. In war, I am certain that clinical pragmatism will prevail because our operational experience has shown it to be true.

What perhaps worries me more is that we are bound by a treaty, the Geneva Convention, that we observe being widely and consistently abused. The Red



Cross has become a targeting symbol in order to undermine the moral component of fighting power. While NATO will continue to obey the principles of the convention we do realise that the same behaviour is not expected of future adversaries, including Russia. In this context, an open display of the emblem may be dangerous, leading to a need for camouflage and concealment of medical facilities that would have previously been advertised.

While I have said there are five principle challenges, there is a sixth consideration—and that is the application of hard-won lessons from contemporary conflicts. I have codified medical lessons learned from Russia's war against Ukraine within an article published last year in Open Access.<sup>3</sup> I have called them the 'Dirty Dozen' lessons, and I have confirmed their validity with the Ukraine Surgeon General directly.

In parallel has been the US Army's independent analysis of lessons from the war,<sup>4</sup> which notes that the findings are very similar and reinforcing to those made by the UK. I would like to also draw attention to the Ukraine Medical Study Group's work to manage a series of focused lessons symposia in Warsaw, funded by US DoD, and capturing key observations

and experience of Ukraine Armed Forces' medical personnel, together with foreign nationals who have been in country to deliver care. NATO's Military Medical Centre of Excellence in Budapest has also captured lessons from across the alliance, from provision of equipment and training through to treatment of casualties evacuated to allied nations.

Importantly, it is through the analysis and synthesis of these lessons that we will gain the wisdom to continuously drive capability development for our war injured. It is a recognised and recurring paradox that medicine advances in war with military-led medical innovation, driven by the casualty imperative, translating into parallel civilian healthcare benefits. This sharing of medical advancement between nations and across the civil-military healthcare enterprise is the very precept on which ICMM was founded in 1921. I urge you to exploit the unusual opportunity from this conference to its full—to make connections, to build relations, and to share experience—so that even in the undesirable event of war, we can guarantee that one survivor will be our shared humanity and our shared purpose as military doctors—which is our primary and unifying aim to do the very best for our patients.

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# Melanoma in Aircrew and Defence Force Members: A Narrative Literature Review

C E Scarff

## Abstract

Melanoma is the most serious form of skin cancer. While classical risk factors are well described, the literature debates whether specific subgroups in the community have an increased risk of developing the condition. These include those who work as aircrew or in the defence forces. While occupational skin cancer is increasingly recognised, it is likely still under-reported. This narrative literature review explores the published literature on melanoma, focusing on aircrew and Defence Force members, as results have potential implications for these workers' selection, protection and surveillance. Many but not all studies show that aircrew and Defence Force members may have an increased risk of melanoma, but gaps in the literature are highlighted. In particular, much of the data reviewed is from several years ago and primarily relates to Northern Hemisphere settings. The importance of exploring the current context in the Australian setting to inform future practice is outlined.

## Introduction

Melanoma is a malignant skin tumour with the potential to metastasise<sup>1</sup> and lead to premature death. While classical risk factors, such as a tendency to sunburn and a phenotype of pale skin, hair and eye colour, are well described, the literature also reports several groups with a higher incidence of melanoma. These include aircrew and Defence Force members. The importance of exploring an association between occupational factors and an elevated risk of melanoma is critical. If found, this may have implications for informing workers – past, present and future – about risks they may face. There are implications concerning selecting workers for specific jobs and developing and improving methods to protect them from melanoma. In addition, there are implications related to the monitoring for the occurrence of disease and actions to be undertaken

if melanoma does occur. Conversely, if a link between melanoma and occupation is not found, such information can reassure those involved. This literature review aims to explore the published literature on melanoma in occupational groups, focusing on aircrew and Defence Force members.

## Materials and methods

This work presents a narrative scoping literature review on melanoma focusing on aircrew and Defence Force members. This style was chosen to permit the location and inclusion of as much information as possible through not being limited to a particular research question. However, as narrative reviews are vulnerable to limitations in several areas, including reproducibility, the search method is outlined here. Using terms related to melanoma and aviation, PubMed was searched in June 2022 (Table 1).

**Table 1: Search terms used for Melanoma in Aircrew and Defence Force Members: a narrative literature review.**

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melanoma OR malignant melanoma OR melanoma in situ OR skin cancer OR skin neoplasms	AND	pilot OR air crew OR cabin crew OR military personnel OR military member OR defence personnel OR defence member OR occupation OR aviation OR flight crew OR occupational exposure	NOT	pilot study OR pilot trial
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The title and abstract (where available) for each paper in English were reviewed. The full text was obtained (where available) for all papers that discussed an element of melanoma concerning aviation or an occupation or hobby considered relevant (for example, one that discussed occupational exposures such as oils that aircrew may be exposed to). Additional articles were reviewed while preparing the literature review until Dec 2022, amounting to over 200. Data was extracted from articles and arranged into the themes presented in this review. Articles included original research articles, yielding empirical data<sup>2-4</sup> and review articles.<sup>5</sup> Article reference lists were also reviewed, and any considered to contain relevant information based on the title review were obtained and included.

Consistent with a narrative literature review, a quality assessment of articles was not performed. Findings are presented in three themes: Occupation and melanoma, Melanoma and aircrew, Melanoma and Defence Force members.

## Results

### Occupation and melanoma

‘Since exposure leading to skin cancer takes place over a long period of time (in most cases several decades), differentiation between occupational exposure and recreational exposure is problematic.’<sup>6</sup>

Determining a relationship between melanoma and occupation is not a simple process and is further complicated by the increasing incidence of melanoma, which occurs with age.<sup>7</sup> As skin cancer has not been regarded as a traditional occupational condition, it is likely that its incidence as a potential occupational disease is under-reported.<sup>6</sup>

While UVR is the most accepted risk factor for melanoma,<sup>1</sup> and recognised by the International Agency for Research on Cancer to be carcinogenic to humans,<sup>8</sup> it is not universally accepted that workplace exposure leads to the development of melanoma. For example, a 45-year historical cohort study from five Nordic countries reported that occupation provided only a modest input to the relative risk of melanoma, with a lowered risk seen for outdoor workers.<sup>9</sup> In this work, the highest risk of melanoma for males was seen in dentists, with others at risk, including Defence Force personnel. However, the local context, including the relatively low UVR levels in the Nordic climate<sup>9</sup> and other confounders, including socioeconomic status, are relevant and may differ markedly from the Australian setting.

Beyond UVR, the literature also reports many other examples of associations between non-solar factors and melanoma development. These include various chemical compounds (e.g. polychlorinated polycyclic aromatic hydrocarbons, benzene and polychlorinated biphenyls [PCBs]),<sup>10</sup> non-solar radiation, including ionising radiation, and trauma.<sup>11</sup> A literature review focusing on non-solar occupational risk factors for melanoma highlighted a wide range of industries of concern, from the petroleum, printing, electronics and electrical, to chemical, clothing and metal industries. Workers in biomedical research, farming and agriculture, and aircrew and radiation workers have also been shown to have increased rates of melanoma.<sup>10</sup> Subsequent reports have highlighted many other occupational and hobby groups as potentially associated with an increased risk of melanoma, including firefighters,<sup>12-14</sup> police force members,<sup>13,14</sup> and again, pilots and aircrew.<sup>5</sup>

While the relationship between occupation and an elevated risk of melanoma is challenging to determine, the importance of investigating this for the health of the vast array of workers potentially at risk is evident.

### Melanoma and aircrew

The incidence of cancers in aircrew has been the focus of numerous studies over many years. Several have reported greater than expected levels of some cancers, including melanoma and propose and explore possible reasons for this. Several highlight potential occupational exposures that aircrew face, including some of the hazards outlined in the previous section. Exposure to ionising cosmic radiation<sup>15</sup> is considered in many. The fuselage of an aircraft does not completely shield against ionising radiation,<sup>18</sup> (including gamma rays and neutrons from galactic and solar radiation sources<sup>16,17</sup>) which is present at cruising altitudes<sup>19</sup> and results in doses above those experienced by the general population. Aircrew likely have the highest radiation exposure of any occupation.<sup>18</sup> The radiation levels aircrew are exposed to vary with many factors, including the type of flight and number of hours flown,<sup>20</sup> the latitude, the altitude and the time of flight,<sup>17</sup> with greater exposures occurring during flights at high altitudes and closer to polar regions.<sup>21</sup> Other variables, such as solar flares, also affect exposure.<sup>21</sup> Personal conventional dosimeters unfortunately do not detect all components of radiation exposure,<sup>20,22</sup> so they have limitations in recording aircrew exposures. While program dose estimation software is reported to be accurate in providing an estimate of individual exposure doses,<sup>22</sup> authors have shown that calculated data may underestimate the radiation dose crew are

exposed to, owing to significant variations in solar flares.<sup>17</sup>

Aside from ionising radiation, the other potential health hazards that aircrew may be exposed to as part of their work include altered sleep patterns,<sup>21</sup> alternation to circadian rhythm (though others argue against this),<sup>23</sup> electromagnetic fields from instruments in the flight deck, chemicals including jet fuels and engine emissions, pesticides and previously also, passive smoking.<sup>20</sup> A combination of these factors may also be relevant. For example, aircrew are often exposed to ionising radiation and disturbance in circadian rhythm together,<sup>24</sup> making the contribution of each challenging to determine.

Of particular relevance to melanoma, several recent works have measured UVR levels in the flight deck during flight. While UVB and UVC radiation were not detected, UVA was seen to be present in several aircraft,<sup>25,26</sup> though at lower levels than at the ground.<sup>26</sup> However, Sanlorenzo and colleagues' earlier work contrasts with some of these findings, as they report that pilots flying at 30 000 feet for just under an hour would receive an equivalent UVA dose to that received from 20 minutes in a solarium. They note this could be even greater when flying over snow or thick cloud due to the reflection of a majority of the radiation<sup>27</sup> and pose a real risk to the crew.

Determining whether the multitude of varying risk factors that aircrews face translate into subsequent disease development is critical to investigate.

As outlined, several studies have reported on the occurrence of melanoma in aircrew, with an increased incidence seen compared with that of the general population or particular subgroups. Studies have employed various data collection methods, including self-report only in surveys or interviews,<sup>28</sup> or data from cancer registries.<sup>29,30</sup>

Several published works, including systematic reviews and meta-analyses, have reported pilots and cabin crew to have approximately twice the incidence of melanoma compared with that of the general population.<sup>5,15,31</sup> Concerningly, Miura and colleagues' systematic review also found that pilots were twice as likely to die from melanoma compared with the general population.<sup>5</sup> A limitation of many of the included studies relates to the age and data sources – most being from decades ago, largely from the Northern Hemisphere and with male data often predominating. In contrast, a more recent study on Australian commercial pilots for 2011–16<sup>4</sup> did not find an increase in rates of invasive melanoma compared with the general population and only a

modestly raised incidence of melanoma *in situ*. This was suggested to relate to increased surveillance with the lack of variation of melanoma on the body site compared with the general population arguing against an occupational cause.<sup>4</sup> The contrasting findings of this study to most previous ones may be explained by the higher baseline of UVR exposure in Queensland, Australia, where the greatest proportion of cases resided.

## Melanoma and Defence Force members

Similar to reports with aircrew, some authors have reported a higher incidence of melanoma in members of the defence forces.<sup>32</sup> Again, some works have found particular subgroups (e.g. older members)<sup>33</sup> to be at greater risk for melanoma and two<sup>32,34</sup> found Air Force members to have higher rates compared with members of the other services (though it is noted one study did not require histological confirmation of melanoma).<sup>34</sup> Compared with civilian workers, members of the defence forces may face extended and more extreme working conditions and a reduced ability to use sun-protective methods as designed or recommended,<sup>35</sup> which may lead to an increased risk of disease.

However, as with melanoma incidence in aircrew, not all studies of melanoma in Defence Force members have shown them to have elevated rates.<sup>13</sup> In other studies, though a small increase in melanoma incidence may be observed,<sup>36</sup> no significant or excess occupational disease was found. Durmishi and colleagues found that defence personnel in Albania self-reported an increased number of risk factors for melanoma (including a history of melanoma) compared with the general population, which may, therefore, confound occupational factors.<sup>37</sup> Of the few Australian studies, one reported male Department of Veterans' Affairs clients to have a statistically significantly increased risk of melanoma but not of increased risk of death from melanoma,<sup>38</sup> and another showed melanoma incidence was elevated in Australian male Vietnam veterans compared with the Australian community.<sup>39</sup> In contrast, a case-control study of white males from Queensland did not find evidence of an association between previous military service and an increased risk of melanoma.<sup>40</sup> The pattern of sun exposure and subsequent risk of melanoma is relevant and has been considered in some studies. For example, non-significantly higher mortality from melanoma was seen in US male Army World War II veterans who had been prisoners of war (POWs) in Pacific settings compared with those who had been POWs in Europe or were not POWs.<sup>41</sup> While many potential confounding factors were also present here, the authors argued that this difference

in outcome reflects the impact of a high but short duration of UVR exposure in young adulthood and the development of melanoma years later.<sup>41</sup> As with aircrew, a combination of potential exposure risks may be relevant, such as an increased incidence of melanoma and prostate cancer that was observed in a group of US Air Force Vietnam veterans who sprayed dioxin-based herbicides compared with national rates of cancer.<sup>42</sup>

Within the defence forces, pilots and aircrew were reported to have higher (though non-significant) rates of melanoma compared with other officer groups as early as 1983.<sup>43</sup> Fixed-wing pilots and crews saw the highest incidence rates of melanoma in the US Military and an exponential increase in melanoma diagnosis from their 7th to 20th year of service, equating to a 16 times greater rate.<sup>44</sup> Defence force pilots are reported to be healthier compared to comparable defence members. They are unlikely to receive the same level of exposure to cosmic ionising radiation as commercial aircrews<sup>21</sup> again, suggesting that other factors may be relevant if a difference is present. The incidence of melanoma in aircrew, compared with that in other US Air Force officers and the US general population, was the subject of a recent US Congress directive.<sup>45</sup> This review of Air Force fighter aviators who served between 1970 and 2004 found that male aircrew were approximately 25 per cent more likely to develop melanoma compared with both groups, equating to 33 additional cases of melanoma in a lifetime for every 10000 aircrew. Concerningly, similar to Miura's study,<sup>5</sup> the findings also showed that aircrew were more likely to die from melanoma compared to the male general population,<sup>45</sup> though at a lower rate.

### Discussion

The findings from this literature review show that aircrew and Defence Force members may be at an increased risk of developing melanoma, though gaps in the literature are noted. Most data are decades old, and workplace practices and aircraft have changed in many aspects since much of this was collected. Further, data is mainly from the Northern Hemisphere, and there is comparatively less about females. Many factors potentially confound occupational ones, including recreational exposure to UVR, the leading risk factor for melanoma, which makes interpretation of associations challenging.

However, as occupational melanoma is an increasingly recognised condition,<sup>12</sup> it is essential to further our understanding of the impact of work on health. Currently, in our society, adults working full-time spend around one-third of their lives at work, meaning there is an increased opportunity for

potential harmful risk factors to impact negatively on health. As such, this literature review calls for action in two areas.

The first is for further targeted, contemporary research. While prospective observational studies would be ideal for accurately measuring exposure related to outcomes and exploring causal inference, the study period required would be extensive, further delaying any required interventions. As alternatives, robust and carefully designed retrospective studies of aircrew and Defence Force members should be employed, comparing cases to controls and exploring other settings and contexts. Such epidemiological studies are powerful tools to inform public health measures, including changes to policy and practice where required and plans for some such studies are underway.

The second area of action relates to managing those potentially at higher risk of melanoma while further research is conducted. While the hierarchy of controls would focus first on eliminating known hazards, this is not always possible. For example, the nature of work in the defence forces, means limiting exposure to UVR is not always practical.<sup>46</sup> Defence members and aircrew should be encouraged to follow current advice around UVR exposure outside of the work context, and tailored occupational advice and education, which differs from population advice, is necessary for outdoor workers and those at increased risk of melanoma.<sup>47</sup> As others outline, such as in Gall et al.,<sup>46</sup> this should include increased education on sun protection, recognising suspicious lesions (and what to do if found). Optimising the use of sun-protective equipment, including uniforms, is also essential. Some authors suggest a work history that includes service in the defence forces, with its potential for unpredictability of work pattern, especially in the deployment context,<sup>35</sup> be considered a risk factor for melanoma, and so prompt more frequent skin examinations, skin cancer screening and early dermatologist involvement for this group.<sup>35</sup> Some authors argue that any period of Defence Force service is relevant to melanoma risk, even if the exposure period is short.<sup>35</sup>

This review has several limitations. As highlighted, studies of aircrew and Defence Force members come largely from Northern Hemisphere settings, and data are primarily from several decades ago. Further, as a narrative review, this work does not seek to answer a specific research question but rather conducts a broad review of published works. The use of one database only may have resulted in missing relevant articles.



## Conclusion

This narrative literature review summarises the literature on the risk of melanoma in aircrew and Defence Force members, suggesting that Defence Force members, particularly those working as aircrew, may have an increased risk of melanoma in specific contexts, though many confounding factors are recognised. This review highlights and calls for further work to explore melanoma incidence in these groups, particularly in the southern hemisphere context to address the gaps in the literature. Such work would have the potential to provide an evidence base to inform future practice changes if required, such as increased surveillance, attention to selection criteria for certain occupations or improvements in and tailoring of sun protection education. The ultimate aim is to improve knowledge, behaviours and outcomes concerning occupational melanoma.

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Optimising care and ensuring this is tailored to occupational settings for those who may be at increased risk of melanoma should proceed in the interim.

## Acknowledgements

The author kindly acknowledges GPCAPT N Abou-Seif, who generated the idea for this review.

## Keywords

Melanoma, Defence Force Members, Aircrew

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# Comparison of a Novel Tool-less External Fixator Clamp with an Established System Regarding Handling and Stability

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## Introduction

With a growing frequency of extreme weather events, associated natural disasters<sup>1</sup> and military conflicts, there is an increasing incidence of fractures requiring emergency treatment in the context of 'damage control' using simple methods such as an external fixator. As Martinez-Rondanelli et al. point out in their 2021 manuscript on damage control in orthopaedics and traumatology,<sup>2</sup> polytrauma stands as a significant contributor to mortality among individuals under 40 years of age, with 55 per cent of these cases involving fractures of the long bones or pelvis. In 31 per cent of the patients, orthopaedic damage control procedures were conducted during the initial surgery.

Although information on the treatment of the consequences of injuries is available from the international community, as in the webinars provided by the AO (Arbeitsgemeinschaft für Osteosynthesefragen) in the context of the war in Ukraine,<sup>3</sup> implementation is limited in disaster situations by the scarce medical infrastructure and quantity of materials available, as recently reported by Médecins Sans Frontières.<sup>4</sup>

If these fractures cannot be treated, they cause not only fatal consequences but also long-lasting disability. Due to the severity of these injuries, the limbs often have to be amputated, even though they could be saved under normal circumstances.<sup>5</sup> In many countries, the loss of a limb leads to disability, combined with loss of income and other severe consequences for the individual and their family.<sup>6</sup>

The external fixator is the method of choice in emergencies when fractures cannot be treated using a cast due to soft tissue damage or gross instability. Further, as Dunn et al. pointed out in their 2022 article on damage control,<sup>7</sup> the use

of initial external fixation, in contrast to definitive internal fixation, aims to reduce the occurrence of post-operative systemic inflammatory response syndrome, multiorgan dysfunction, overall surgical complications, acute respiratory distress syndrome, surgical blood loss and reduces the duration of the procedure, which in return reduces the chance of perioperative complications.<sup>8</sup>

Commercially available external fixator systems used in these cases have several flaws in disaster situations: they are only available in limited quantities, are heavy and expensive, and require special tools and training.

Attempts have been made to develop 3D-printed clamps,<sup>9</sup> tool-less<sup>10</sup> and low-cost systems<sup>11</sup> with no success combining all features in one clamp.

The project aimed to develop a fixator that bypasses the limitations of being costly, requiring training and the need for special tools. The developed clamp's performance should be tested compared to a commercially available external fixator.

## Materials and methods

The study was carried out within the framework of a translational project by the University Hospital of Hamburg UKE, the BG Klinikum Hamburg and the Bundeswehr Krankenhaus Hamburg (military hospital). As no patients or patient data were involved, the study did not have to be registered in the clinical trial registry. It nevertheless strictly followed a predefined study protocol. No funding was received for the project.

According to current plans, the fixator is aimed to be a disposable external fixator used for temporary care and applied under emergency conditions in natural disasters and military conflicts under limited logistical conditions. Objectives of the system are:



- low-cost manufacturing
- short-term, demand-optimised, decentralised production
- intuitive handling with minimal tools and little training required
- Compatibility with existing systems
- rod-to-pin and rod-to-rod fixation with the same clamp

#### Fixator-System A – Wingman external fixator

The newly developed fixator system can be seen in Figure 1(A) and has been called ‘Wingman’ due to its ergonomic handle shape that is reminiscent of wings that unfold and was developed in association with the company Bluewater Medical (BLUEWATER MEDICAL GMBH, Faulmannweg 5, 24148 Kiel, Germany). The reason for the shape was to increase torque for tightening. A snap-in-retention was built in to avoid unintended unlocking (Figure 1(B)). One coupling could adapt a Ø5 mm shaft pin (Figure 1(A)) and up to two 11 mm rods (Figure 1(B)). The application of the coupling was entirely tool-less. In Figure 2 more detail on undeployed wings (Figure 2(A)) and deployed wings (Figure 2(B)).

#### Fixator System B – AO external fixator

The AO (Arbeitsgemeinschaft für Osteosynthesefragen) Fixator system by Depuy Synthes (Synthes Holding AG, Solothurn, Switzerland) with the tradename ‘Large and medium External Fixator’ (Figure 1(C)) was used as the commercially available model for comparison. It had a modular clamp to rod-to-pin system with a clip-on self-holding mechanism made from titanium constructed for 5mm pins and 11 mm rods. An 11 mm combination wrench was used for tightening the clamp. This setup has been used in studies before.<sup>12</sup>

#### Pins, rods and bone model

Each fixator setup was constructed of four self-drilling half pins (Ø5 mm, 150 x 50 mm), model Apex by Stryker (Stryker GmbH, Selzach, Switzerland), which were driven into a synthetic bone (left femur with distal canal opening, Synbone, Switzerland. Length: 460 mm. Condylar width: 85 mm. Neck angle: 120°. Anteversion: 18°. Head diameter: 49 mm. Canal diameter: 10 mm) with a standard Cordless screwdriver (Model GSR 12V-15 PROFESSIONAL by Robert Bosch Power Tools GmbH, Leinfelden Echterdingen, Germany).

Figure 1 Comparison of both systems set up

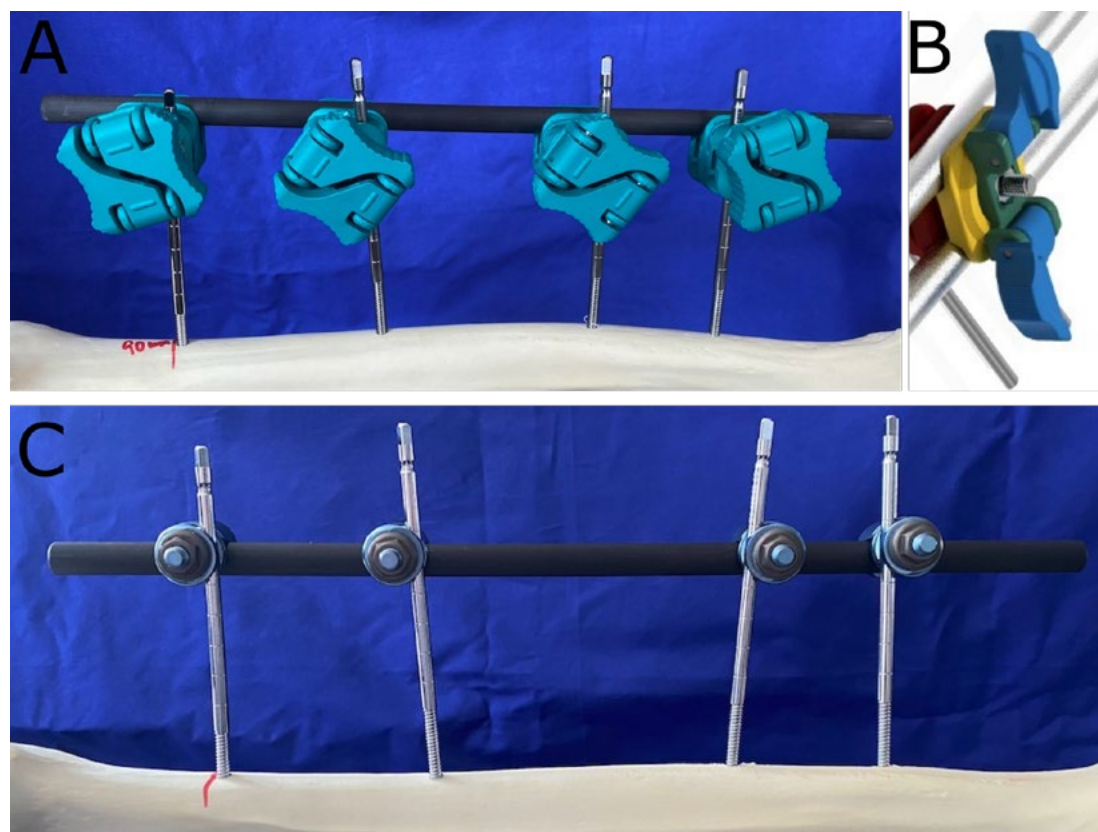
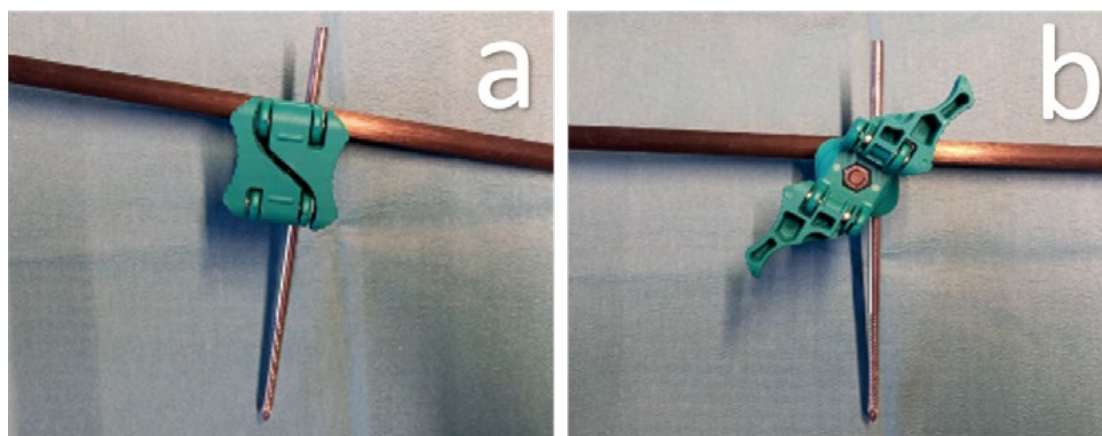


Figure 2 Deployed and undeployed clamps



### Subjects applying the systems

The system was applied by surgeons who were divided into three groups, each with eight subjects of varying surgical experience, resulting in a total of 24 surgeons:

- Group 1  
Surgeons working in trauma surgery with 0–3 years of professional experience were described as residents with the lowest experience level.
- Group 2  
Surgeons with more than 3 years of experience in trauma surgery but without successful examination in ‘Special Trauma Surgery’ are described as fellows having a medium level of experience.
- Group 3  
Experienced surgeons in trauma surgery with the designation described as attendings.

### Procedure for the application of the systems

One run with each fixator model was carried out per surgeon in a cross-over design according to ABBA scheme (Surgeon 1: fixator A followed by fixator B. Surgeon 2: fixator B followed by fixator A) to reduce bias due to a learning effect. The fixation was carried out in orientation on the standard principles of ASTM F1541.<sup>13</sup> The surgeons were free to place their pins, sparing the area where the condyles were placed in a footing and the osteotomy zone. The time measurement was carried out from the placement of the pins in the bone to the completed placement of the connecting rods of the fixator and fully tightened clamps.

Once the fixator was in place, an oscillating saw was used to simulate an unstable transverse femoral shaft fracture according to AO 32A3(b), followed by

mechanical testing.

### Mechanical testing

A simple quasi-static mechanical test was used to measure the stability of the individual surgeons’ setup. The static test was performed based on annex 7 of the ASTM F1541 [7], which describes a test method for the complete skeletal fixator-bone construct. Compared to the testing standard of external fixators, a test scenario was used to investigate the individual setup of the surgeons, as the focus was on the time needed to apply the system rather than implant it in a standardised fashion. The distance between the rod and point of force application was set to 155 mm while the individual pin placements were kept in place. The tests were performed with a Zwick Roell 1455 RetroLine (Zwick Roell AG, Ulm, Germany), which can be seen in the test setup in Figure 3. The setup was based on a biomechanical degree of freedom analysis of the human femur. The femoral head was able to rotate freely. The femoral condyle was mounted allowing no torsion but leaving 30 mm into anterior-posterior and lateral-medial direction. A maximum load of 150 Newtons was selected, corresponding to the approximate force due to the leg’s weight (18.5% of body weight<sup>14</sup> for an average of 77 kg<sup>15</sup>).

For each test, two similar measurements were performed. The first measurement was performed to diminish the system’s slack due to the installation of the test. The second measurement was used as a basis for the comparison of both systems. The recording of the measurement started at 5 N. The table speed was set as 1 mm/s. After 150 N were reached, the load was reduced until 5 N were reached, and the recording stopped. The deformation was measured in mm. In Figure 3, both systems can be seen under load and without load.

Figure 3 Comparison of Fixators under load

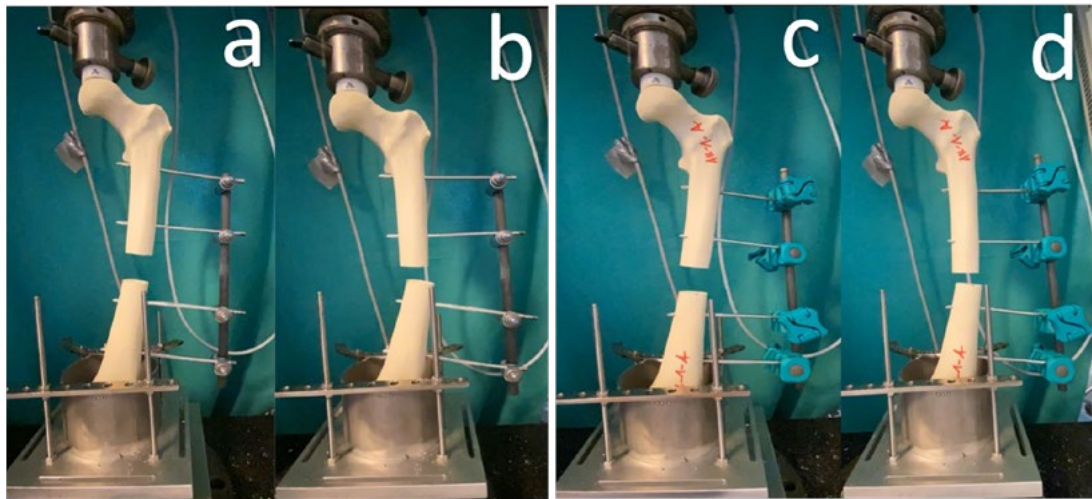
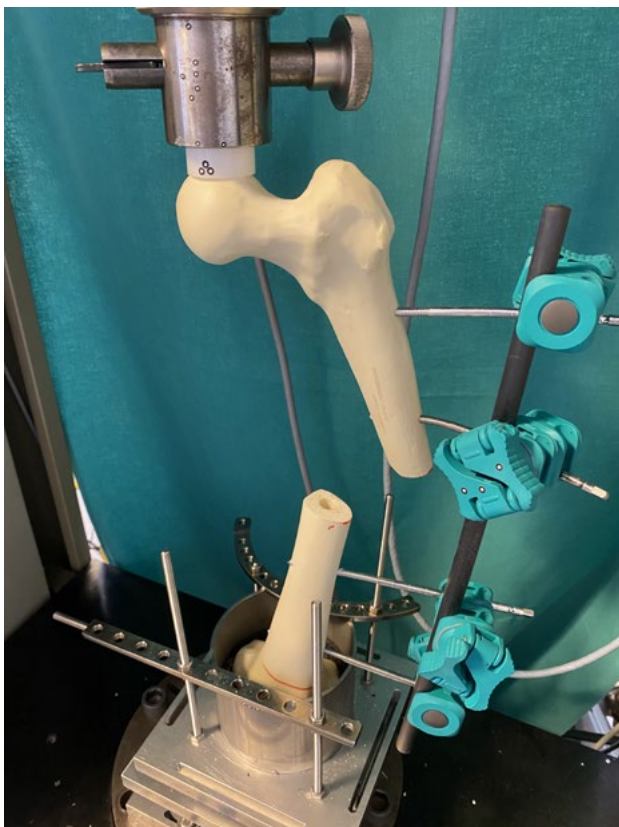


Figure 4 Clamp failure



The resulting failure rate was compared for fixator systems A and B. Failure was defined as the inability to withstand 150 N due to movements between connected parts and deformation. An example of a failed construct can be seen in Figure 4.

#### Statistical methods

A direct comparison between groups was carried out regarding the fixator system first applied using a Chi-Square test. The overall time needed to apply the fixator system and the deformation during material testing were tested using a Wilcoxon Rank-Sum test. SAS statistical software was used for calculating the results.<sup>16</sup>

#### Results

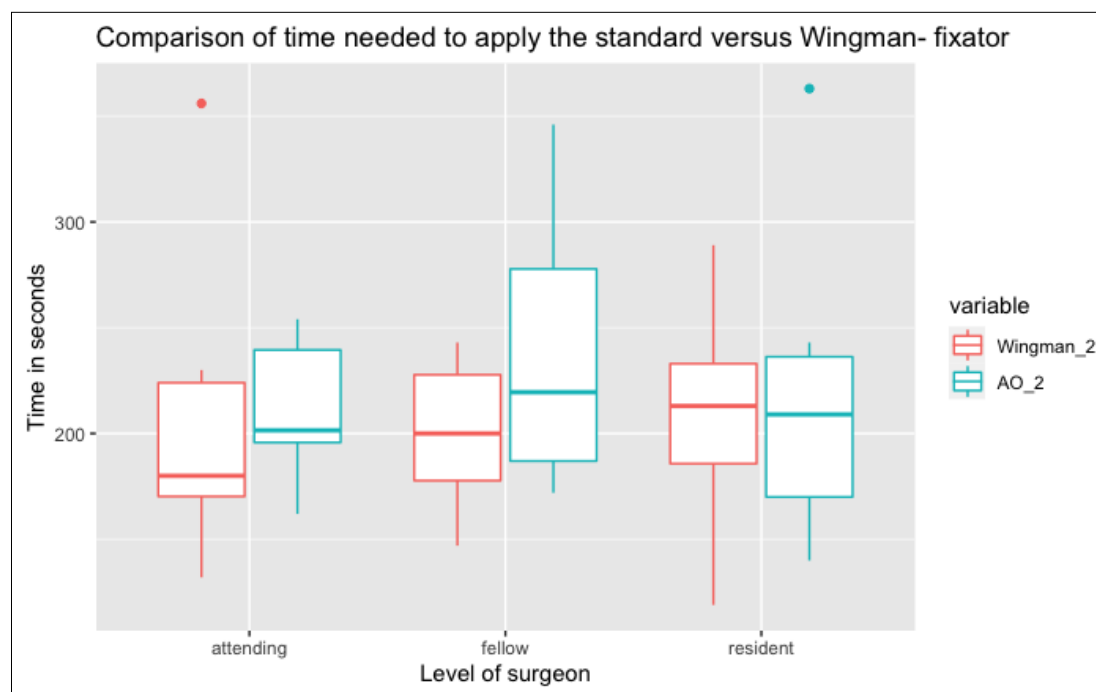
In total, 24 surgeons divided into three groups of eight, with varying surgical experience (resident, fellow, attending), applied each external fixator system to one synthetic left femur, making up a total of 48 constructs that were tested.

First, we measured the overall time needed for each surgeon to apply each system and compared the results. It showed no significant difference ( $p=0.06$ ) in a Wilcoxon Rank-Sum test. When looking at it as a race with the system applied first as the winner and the system applied second as the loser, 16 out of 24 surgeons had the Wingman fixator applied before the AO system, making it significantly faster in comparison to the AO fixator ( $p=0.02$ ) in a Chi-Square test.

A comparison of the time needed to apply both systems can be seen in Figure 5. A tendency of the Wingman fixator to be faster can be retraced graphically by



Figure 5 Boxplot of times



comparing a steady reduction of median time needed to apply the system in comparison to the AO fixator.

One sample failed in each group of 24 setups, not reaching 150N of axial load during biomechanical testing. When deformation was compared, the Wilcoxon Rank-Sum test showed no statistically significant difference between both groups ( $p=0.33$ ).

## Discussion

Tool-less external fixators are currently not state-of-the-art in military and disaster applications. However, the developed system has some unique advantages due to the manual locking clamp mechanism.<sup>10</sup> Especially in combat situations, in which time and weight optimisation is an asset, lightweight and quickly adaptable systems are preferable if they achieve equivalent results. Therefore, the study's primary aim was to compare the performance of the novel tool-less system to the commercially available and established AO external fixator. The novel system showed equal failure rates when tested for stability while showing no inferiority when the time needed to set up either system was compared, in line with the Wingman's goal to provide an intuitive handling while being safe to set up by novel users.

Numerous studies have explored possibilities to bypass the inherent obstacles of commercially available external fixators. For example, Landaeta et al. recently tested a 3D-printed clamp for external

fixation following the ASTM standard F1541 showing that its biomechanical properties were comparable with other currently available external fixators.<sup>9</sup> Similar to this study, a unilateral fixator with one rod was used.

Goh et al. took a similar approach to our setup, testing an AO external fixator to a novel low-cost fixator, not finding a statistically significant difference in stiffness.<sup>17</sup>

A tool-less external fixator named 'Dolphix Temporary Fixation System' was biomechanically evaluated in comparison to the Hoffmann III System by Stryker by Carpanen et al.<sup>10</sup> The tool-less system exhibited 54 per cent of the strength of the Hoffmann system. In contrast to the Wingman clamp, the system needs one clamp for a pin-to-rod fixation and one for a rod-to-rod fixation, whereas the Wingman clamp can be used for both purposes. On top, the Dolphix system was not intended to be 3D printed.

Kouamé et al. tested a low-cost conventional external fixator compared to the Hoffmann III model by Stryker and found no inferiority of the low-cost system.<sup>11</sup>

An experimental setup comparing the time needed to apply different external fixator models could not be found. Kienast et al. compared the 'plate to bone fit of manually bent reconstruction plates with two industrial pre-bent clavicle midshaft plates' also



using three differently experienced surgeons.<sup>19</sup> Significant differences between the groups regarding the time needed for bending the plate could not be identified.

The Wingman clamp showed no inferiority to the AO system when it came to the time needed to apply it with equal failure rates. This proves its intention of needing no prior training when applied by any surgeon, no matter which system they had trained on.

While testing the application of both external fixator models, the participants noted that one advantage of the system is that a reposition of a fracture could be held while the fixator clamp could be single-handedly fastened. In clinical practice, holding reposition is usually done by one surgeon while the other surgeon fastens the clamps using special tools. In precarious situations during warfare, as currently reported by the WHO in the Ukraine,<sup>20</sup> a system saving technical and personal resources can be beneficial.

A potential subject for further studies would be testing a modular external fixator system setup recommended by the AO<sup>21</sup> using the Wingman external fixator clamp compared to a conventional external fixator clamp to see how it performs in more complex setups.

### Limitations

In this study, a monotube system was applied and tested. Biomechanically, a double tube system has superior stability.<sup>22</sup> As applicability was the focus of this study, only one tube was used.

As the surgeons knew which system they were using, a performance bias cannot be excluded due to preconceived notions or preferences for one system.

Despite a current global mismatch between the availability of 3D printing and demand for it in developing countries or regions of a humanitarian crisis, market potential is seen by Corsini et al. regarding supply chains, making the approach of the Wingman external fixator prospectively sustainable.<sup>23</sup>

### Summary, conclusion and outlook

In this study, three groups of eight surgeons with different degrees of experience tested the performance of the novel tool-less external 'Wingman' fixator clamp in comparison, designed to be used during warfare and humanitarian crises, to a commercially available and established AO external fixator system. The novel system proved to be significantly faster to set up, not significantly less time consuming, with identical failure rates, pointing towards a superiority of the Wingman external fixator system.

The low amount of metal could allow MRI compatibility compared to conventional fixators, especially when glass fibre rods rather than metal tubes are used, yet this has to be evaluated and is subject to further projects.

Of all the objectives set initially, the cost factor could yet not be finally determined. The cost depends on the production scale and its possibility of decentralised production by 3D printing on demand wherever the external fixator is needed and will be subject to future projects.

Despite the intention to be used in a setting of limited medical infrastructure, the Wingman external fixator has the potential to be used in civilian circumstances due to MRI compatibility and overall good handling and performance. Its clinical implementation is the next step, possibly also in civilian use.

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# Caring for Post-9/11 Veterans in the Civilian Sector: Knowledge and Readiness of Registered and Advance Practice Nurse Providers

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## Abstract

**Importance:** Since 2001, 3.5 million United States service members deployed overseas in support of the post-9/11 Global War on Terror. While healthy and fit upon deployment, veterans have experienced many complex and often unexplainable illnesses and chronic diseases, with more than 520 000 being diagnosed with cancer. With the implementation of the VA MISSION and PACT Acts, post-9/11 veterans are increasingly being seen in non-VHA healthcare facilities by non-physician providers.

**Objective:** To assess the readiness of registered and advanced practice nurses to provide knowledgeable and competent healthcare for post-9/11 veterans in the civilian healthcare system.

**Design, setting and participants:** A web-based survey was administered by the HunterSeven Foundation (a Veteran-founded non-profit organisation), with 541 nurse respondents.

**Primary outcomes and measures:** Questions were designed to assess military knowledge, comfort level caring for veterans, self-reported proficiency and prior training of participants. Mean differences were compared using a restricted maximum likelihood, fixed-effects model, with incidence between groups estimated as log-binomial relative risks.

**Results:** Meaningful gaps in clinical knowledge of screening for and treatment of medically related conditions were identified. Our assessment also highlighted a sparseness of knowledge for making care recommendations based on apposite resources.

**Conclusions and relevance:** Cognitive biases among healthcare providers in the civilian sector may lead to missed and/or delayed diagnoses, therefore emphasising the need for additional training focused on caring for post-9/11 veterans.

**Keywords:** Civilian healthcare setting; global war on terror; knowledge and readiness; veterans

## Key points

**Question:** Are civilian (non-VHA) nurses competent and knowledgeable to provide healthcare to post-9/11 military veterans?

**Findings:** Results from our survey of 541 respondents suggest that many nurses employed in the civilian setting do not have ideal knowledge and understanding of post-9/11 military veteran-related risk factors and healthcare concerns. However, nurse respondents with a history of military service were significantly more familiar with the five key areas of military knowledge (i.e., war-reported illness, traumatic brain injury, psychological impact, military veteran culture, and resources available) than non-veteran nurse respondents. This difference was also true for surface-level knowledge of mental health concerns, combat exposures, healthcare use, demographics and medical outcomes. Having a post-baccalaureate degree did not correspond to greater military knowledge.

**Meaning:** Non-VHA nurses may benefit from additional training focused on the needs of post-9/11 veterans receiving care in the civilian healthcare setting.

## Introduction

### Background

The United States has deployed over three million uniformed service members to areas in the Middle East and Southwest Asia in support of the Global War on Terror since the turn of the 21st century.<sup>1</sup> While research is limited and preliminary, the data suggests that veterans who have deployed to Iraq and/or Afghanistan are more likely to experience chronic physical symptoms, increased shortness of breath and a decreased level of physical fitness post-deployment compared with pre-deployment.<sup>2-4</sup> Prior data extracted from medical records suggests that the same population is experiencing chronic, complex, terminal and otherwise unexplainable medical issues. This includes rare forms of cancer occurring at increased rates than their non-veteran, civilian counterparts with similar demographics.<sup>5</sup>

Most of the literature surrounding post-9/11 service members focuses mainly on mental health, post-traumatic stress disorder and suicidality. Few studies addressed the relationship between non-VHA healthcare providers, specifically those in the nursing profession, and care provided to veterans. A 2015 Congressional Appropriations Committee report suggests that 26% of post-9/11 veterans were enrolled in and received care from the Veterans Health Administration (VHA). This led researchers and committee members to believe that the remaining use civilian-based (non-VHA) medical facilities.<sup>6</sup> While it is assumed that healthcare providers who work in a military or VHA setting offer culturally competent care to veterans, it is important to examine the level of cultural competence among non-VHA healthcare providers.<sup>7,8</sup>

The information available on this topic highlights an increasing gap of concern, considering post-9/11 veterans account for approximately 19% of the total veteran population. According to projections provided by the Joint Economics Committee, this number is expected to increase to 32% by the year 2034.<sup>9,10</sup> As part of the HunterSeven Foundation's Military Exposures Education and Awareness initiative, this manuscript aims to describe the level of knowledge, beliefs and perceptions among civilian nurses in providing care to post-9/11 veterans. An important premise is that registered and advanced practice nurses should have basic knowledge about military culture, military experiences and the possible health-related consequences of service to provide adequate and competent care to veterans in a non-VHA setting.

### Current knowledge

Post-9/11 veterans are defined as those who have served in the US military (Army, Navy, Marine Corps and Air Force) and have been deployed to Iraq, Afghanistan, Syria or Kuwait on or after September 11, 2001 (including Operation Enduring Freedom, Iraqi Freedom, Inherent Resolve, New Dawn and Resolute Support).<sup>11</sup> Although young (~35 years in age), these veterans encountered high-risk, diverse experiences and may manifest unusual health outcomes as a result.<sup>5,12</sup> Respiratory disorders, eosinophilic lung disease, asthma and an array of presumptive conditions, including rare forms of malignancies, began to appear in the months and years following deployments to Southwest Asia.<sup>13</sup>

### Unique healthcare needs of post-9/11 veterans

#### Mental health

Many veterans of the post-9/11 cohort were exposed to improvised explosive devices (IED) and blasts consequent to serving in and travelling through active war zones.<sup>14</sup> In addition, there has been a sizeable uptick in claims for mental health conditions, although many cases go undetected until veterans experience other life crises. While the mental health burden experienced by post-9/11 veterans is well recognised, it has not been acknowledged as a potential barrier to accessing care for other health concerns.

#### Primary cancer diagnoses in post-9/11 active-duty service members

A twenty-year review of the primary diagnosis of cancers in active-duty service members by the Department of Defense (2001–2021) found that those who served on active duty were more likely to be diagnosed with malignancies than civilians. This determination was made by comparing the National Cancer Institute Surveillance, Epidemiology and End Results (SEER) Program's reporting of cancer diagnoses in the US population by year (age-adjusted) with the Department of Defense Military Health System Data Repository cancer diagnoses.<sup>15,16</sup> Rates of the most commonly diagnosed cancers (i.e., prostate, lung, colorectal, bladder cancers and melanoma) are 1.4% higher among veterans than civilians.<sup>17</sup> Furthermore, post-9/11 veterans averaged 5.2 cases of brain cancer (mostly glioblastomas) per 100 000 per year from 2015 to 2019 among those aged 30–39. In an article published on Military.com, data from the VA and NIH suggests glioblastomas occur at a rate 26% higher in the post-9/11 veteran cohort in comparison to the US non-veteran population.<sup>18</sup>



Military hazards and potential exposures can vary depending on geographical location, service members' role and assigned duties.<sup>5</sup> Several factors may affect the development of health problems after leaving military service. Hazards may depend on jobs performed, exposure to military-grade fuel, airborne emissions from mechanical equipment, geographical air pollution and high levels of particulate matter in their location of deployment (e.g., Afghanistan and Iraq).<sup>5,13</sup> Reported exposures among post-9/11 veterans included combat-related smoke, burn pits (i.e., medical and human waste, tires/rubber, plastics, toxic chemicals, benzene-based jet fuel propellant and general refuse/debris), geologic dust, IED, asbestos and depleted uranium. Vaporised depleted uranium-contaminated dust and soil create a long-term health risk owing to the long half-life of this radioactive, cancer-causing element. Over 85% of those deployed to Iraq and Afghanistan had burn pit contact.<sup>19</sup>

Ninety per cent of those deployed reported post-deployment exposure-related health concerns. The majority of post-9/11 veterans receiving care at the VHA since 2002 have been seen for various medical concerns (e.g., endocrine, nutritional, metabolic, digestive, respiratory and ill-defined conditions).<sup>5</sup> The healthcare needs resulting from military service place these veterans at an increased risk for health conditions compared with civilians.

Post-9/11 veterans who were exposed to airborne toxins during their deployment frequently reported an increase in respiratory-related symptoms and a decrease in physical fitness status.<sup>4</sup> The hazards exceeded safe exposure guidelines which coincide with deployment periods.<sup>4</sup> Overall, participants were young and did not fall into the demographic of those experiencing specific adverse health conditions (i.e., those with chronic or terminal illnesses that are more commonly seen in the older general population versus a previously healthy and fit military cohort). These findings highlight the importance of a nurse's role in healthcare, specifically in patient assessment, education, navigation and advocacy.<sup>4</sup> With cancers being more prevalent in veterans, mental health concerns and other comorbidities can present as challenges that may interfere with cancer identification and treatment.<sup>20</sup>

### Veteran healthcare use

In August 2014, the US Congress passed the Veterans Access, Choice, and Accountability Act (VACAA) in response to the VHA's inability to provide timely access to healthcare for veterans and their families. The passing of VACAA established the Veterans

Choice Program (VCP) that covers veterans seeking treatment at non-VHA facilities.<sup>21</sup> The recently passed PACT Act in 2022 provides additional coverage for veterans with an expanded list of presumptive health conditions and specifically addresses health-related military exposures.<sup>13</sup>

With the increasing use of community healthcare options, most post-9/11 veterans do not seek medical care or are followed by a provider at the VHA.<sup>22</sup> Knowledge and competency differences between nurses practicing in non-VHA (versus VHA) healthcare facilities are a growing concern and reflect the readiness to provide effective care for this at-risk group.

### Civilian nursing knowledge and understanding of veteran healthcare

Timely and cost-effective healthcare services are critical; however, an understanding of military culture by non-VHA community healthcare providers is essential to prevent poor health outcomes and delayed diagnoses. A recent study assessed how nurses' awareness of veteran healthcare needs affects the assessment, planning, interventions and evaluation of outcomes in this veteran cohort.<sup>8</sup> Nurses typically learn about cultural norms, beliefs and values of specific populations as a component of nursing curriculums. However, those providing care for veterans may benefit from additional training to understand how veterans' individualised experiences influence health needs. Another benefit is gaining perspective on veterans' healthcare in the context of military culture.

Often, military culture has been overlooked, misunderstood and insufficiently addressed by non-VHA nurses.<sup>8</sup> Twelve per cent of non-VHA nurses reported collecting patient military history or related health information. In contrast, 80% of non-VHA nurses reported they were 'completely unfamiliar' or 'a little bit unfamiliar' with support services available to veterans. Additionally, 70% of non-VHA nurses do not inquire about military or veteran status when completing an assessment. Less than 4% of non-VHA nurses within this study understood military culture, and few reported having a military service background.<sup>8</sup>

Veteran reliance on care from non-VHA facilities will increase over the next two decades. Frequently, nurses are the first point of contact for patients receiving care (e.g., initial encounters, assessments and subsequent interactions), therefore, it is instrumental that concerns regarding barriers to care be addressed. This highlights the need for

policyholders and key stakeholders to implement guidelines for non-VHA providers to deliver culturally competent healthcare services. Appropriate guidance and training are key priorities for nursing professionals; however, clarity regarding when and where guidance should be offered is needed.<sup>23</sup>

## Materials and methods

### Instrument

A Qualtrics, online survey in English was administered to participants. The instrument was adapted from the validated RAND Corporation's 'Ready or Not' web-based tool and followed SQUIRE 2.0 standard guidelines.<sup>24</sup> Questions were designed to assess military knowledge, comfort level caring for veterans, self-reported proficiency, and prior training of participants (Appendix A). Before use, subject matter experts in the field reviewed the questions, including nursing professionals, military medical providers and service members. Modifications of the survey were based on a thorough literature review, and changes to the wording were suggested to improve readability. Approval was granted by the HunterSeven Foundation Ethics Review Committee (#HS-0231Z) and the Rhode Island College Institutional Review Board (#2122-2247). The HunterSeven Foundation (a veteran-founded non-profit organisation) distributed the survey, and participation access was open for one month in 2021.

Like the RAND Corporation survey instrument, categorical responses were ranked using a psychometric, 5-point Likert scale for two sections of questions. For Q10.1 through Q10.5, respondents were asked to rate their level of familiarity regarding five specific topics (e.g., war-related illnesses, traumatic brain injuries, psychological impacts of war, military/veteran culture and military/veteran resources) in relation to providing care for post-9/11 veterans, with response options ranging from 1 = completely unfamiliar to 5 = extremely familiar. For Q13, respondents were asked to rate their comfort level for competently caring for post-9/11 veterans, with response options ranging from 1 = extremely uncomfortable to 5 = extremely comfortable.

Participants were also asked a series of dichotomous (true/false) questions (Q11.1 through Q11.7) derived from findings in the literature review pertaining to their surface-level knowledge of post-9/11 veterans, including mental health concerns, combat exposures, healthcare use, demographics and medical outcomes. These were posed as statements requesting participants to decide the accuracy of the response options. This was the preferred

method to gain insight into respondent knowledge. That is, providing a close approximation of inferred mastery using either informed reasoning based on statement attractiveness or informed reasoning with endorsement bias.<sup>25</sup> The definitive knowledge items were Q11.1, Q11.2, Q11.3, Q11.4 and Q11.7, with the first four questions being reverse coded. Two true/false items (Q11.5 and Q11.6) were included as distractor questions without a definitive answer. These questions were included to identify respondents without thorough knowledge of the survey subject matter, under the presumption that the average true/false response would be 50%.

A second set of dichotomous questions (Q12.1 through Q12.5) were related to the respondent's practice assumptions and self-awareness. In particular, the nurses were queried about their beliefs regarding veteran suicidal thoughts, status changes, psychosomatic symptoms (mental) and physical fitness / overall health. They were also asked about their physical safety when caring for veterans.

In the final survey question (Q14), nurse respondents were asked for their professional opinion based on clinical experience regarding the average age range of the general non-veteran patient population they observe and diagnose with cancer.

### Participants

Participants were identified and recruited through professional organisations and social media using a point of reference sample. Registered nurses and mid-level providers employed either full or part-time in non-VHA healthcare practices in the United States (e.g., emergent, urgent, ambulatory care and inpatient specialty departments) were included. For administrative reasons, agency, travel and telehealth nurses were excluded. Age group, gender, level of education, practice location (state) and military service history were collected as non-identifiable, anonymous information in compliance with the US Health Insurance Portability and Accountability Act (HIPAA). No participation incentive was offered.

### State-level data

State-level population data from 2021 were tabulated because variations may affect veterans' healthcare needs and how they receive care.<sup>26</sup> This included the percentage of registered nurses and post-9/11 veterans, as well as the number of VA medical centres per state. Data from states with the most survey respondents were presented to contrast with population-based data. Average responses for Q10 and Q13 and percentages for Q9 and Q11 were included in the table.

### Data collection, missing values and statistical analysis

Questionnaire information was converted into numerical identifiers and entered in SAS 9.4 (SAS Institute, Cary, NC) and SPSS Version 26.0.1.1 (IBM, Armonk, NY) for analysis. Transformations were applied to the data when appropriate to better accommodate statistical applications. This involved 1) rank-linearising the observations from high to low, 2) right-shifting the results by their least upper bound, and 3) variance stabilising the elements, such that their variability is minimally related to their mean value.

Few observations had missing data (<0.5). An examination of the missing data patterns suggested that the unknown values were not randomly aligned, with unequal spacing between the clusters.<sup>27,28</sup> Accordingly, listwise deletion, which requires the missing data to be missing completely at random (MCAR), was not used when analysing the data.<sup>29</sup>

A multistage, expectation-minimisation (EM) algorithm was implemented to accommodate missing values. This entailed finding maximum 'a posteriori' estimates of model parameters for the set of transformed values for the unobserved latent variables.<sup>30</sup> Euclidean distances between the 'a posteriori' and maximum-likelihood estimates for the respective levels of a variable were computed. The distances were used to partition missing values into their optimal completion categories, akin to a Boolean similarity measure.<sup>31</sup> Different approaches for accommodating binary and Likert-scaled data tend to yield comparable results when the percentage of missing data is low.<sup>32,33</sup>

Descriptive characteristics were tabulated to determine variable cell frequencies, with differences between male and female respondents assessed using Fisher's exact test. For variables with more than five levels, *p*-values were computed by Monte Carlo simulation. The sampling frame consisted of 1 000 000 randomly drawn tables in proportion to their hypergeometric probabilities, conditional on the marginal frequencies (i.e., the same total sample size and row/column totals as the observed table).<sup>34</sup>

Cronbach's alpha was used to determine instrument consistency in subjective responses. In contrast to the Kruder-Richardson (KR) score that can only be computed for dichotomous survey items, the Cronbach's alpha score may be computed for dichotomous and multi-level Likert data to determine internal consistency.<sup>35</sup> A Cronbach's alpha score  $\geq 0.70$  is generally considered an adequate score for a survey tool, consistent with the criterion of

Nunnally.<sup>36</sup> However, this score is not a measure of dimensionality nor a test of one-dimensionality (i.e., one latent variable). An exploratory factor analysis was used to address this question, examining the diminishing total variance explained by each component eigenvalue.<sup>37</sup>

Mean differences for participants with a history of military service versus those without, as well as participants with a post-baccalaureate degree (master and/or doctorate) versus those without, were compared using a restricted maximum likelihood, fixed-effects model, controlling for age group and sex. Fixed-effects estimates are robust for detecting mean differences between two groups, providing that the samples are reasonably large and have few extreme outliers (i.e., finite variances).<sup>38,39</sup>

Adjusted relative risk (RR) was used to compare incidence between groups and computed with a log-binomial model.<sup>40,41</sup> *P*-values were estimated using the likelihood ratio test and denoted as ' $P_{LRT}$ '. Similarly, significance levels corresponding to the additive interaction between groups ( $RR_1/RR_2$ ) were denoted as ' $P_{INT}$ '. Akaike's Information Criteria evaluated goodness-of-fit and case-wise diagnostic statistics, generalised to log-binomial regression.<sup>42</sup>

Unless indicated otherwise, *p*-values less than 0.05 indicated a significant association. Rounding was based upon significant figures rather than fixed decimal places (Goldilocks method).<sup>43</sup>

## Results

### Demographics

A total of 541 eligible participants completed the survey. They varied by practice state, setting, age range, military service history and level of education (Table 1). Thirty-five per cent of participants were aged 20–29 years and 49% were aged 30 to 39 years. The majority (83%) of nurses indicated practicing in a hospital setting (emergency department, inpatient care and intensive care/critical care), with the remaining respondents practicing in management, primary care, mental health, oncology and surgical settings. Ninety per cent reported working full-time (32 hours or more weekly).

All participants were licensed and actively involved in direct patient care, with 69% having obtained a bachelor's degree and 11% a post-baccalaureate degree. Participants predominately identified as female (86%). Sixty-four respondents (12%) reported having served in the military, averaging 7.2 years of service (ranging between 2.5–21 years, median = 6 years). Over half (61%) of the participants stated they

**Table 1. Respondent characteristics by sex (N = 541)†**

Respondent characteristic	Male n (%)	Female n (%)	P-value‡
Total (n)	78	463	---
Age (years)			0.93
20-29	25 (32)	163 (35)	
30-39	41 (53)	224 (48)	
40-49	10 (13)	60 (13)	
≥50	2 (3)	16 (3)	
Employment status (per week)			0.028
Full time (≥32 hours)	4 (5)	20 (4)	
Part-time (<32 hours)	0 (0)	30 (6)	
Per diem			
Military service	30 (38)	34 (7)	<0.0001
Years served in military			1.0
≤4	3 (33)	18 (33)	
>4-6	3 (33)	16 (29)	
>6-10	2 (22)	14 (25)	
>10	1 (11)	7 (13)	
Family member served in military	47 (60)	285 (62)	0.90
Highest degree obtained			0.34
Associate	20 (26)	85 (18)	
Bachelor	52 (67)	320 (69)	
Master	6 (8)	50 (11)	
Doctorate	0 (0)	8 (2)	
Practice setting			0.17
Emergency department	35 (45)	169 (37)	
Mental health	3 (4)	16 (3)	
Acute care (in-patient)	10 (13)	112 (24)	
Case management	0 (0)	5 (1)	
Oncology	1 (1)	11 (2)	
Intensive care	22 (28)	99 (21)	
Surgical	5 (6)	20 (4)	
Primary care	2 (3)	31 (7)	

†Percentages may add up to greater than 100% owing to rounding. ‡Fisher's exact.

had an immediate family member who served in the military. Employment status ( $p = 0.028$ ) and history of military service ( $p < 0.001$ ) differed by sex.

### Frequently occurring health issues

Health issues (Q9) believed to occur among post-9/11 veterans frequently were mental health concerns (e.g., post-traumatic stress, depression, anxiety, suicidal ideation and addiction) (92%); medical illness characterised as pulmonary diseases, cancer and autoimmune disorders (7%); and physical injury (e.g., amputations, musculoskeletal injuries, brain injuries) (1%).

### Knowledge and preparedness

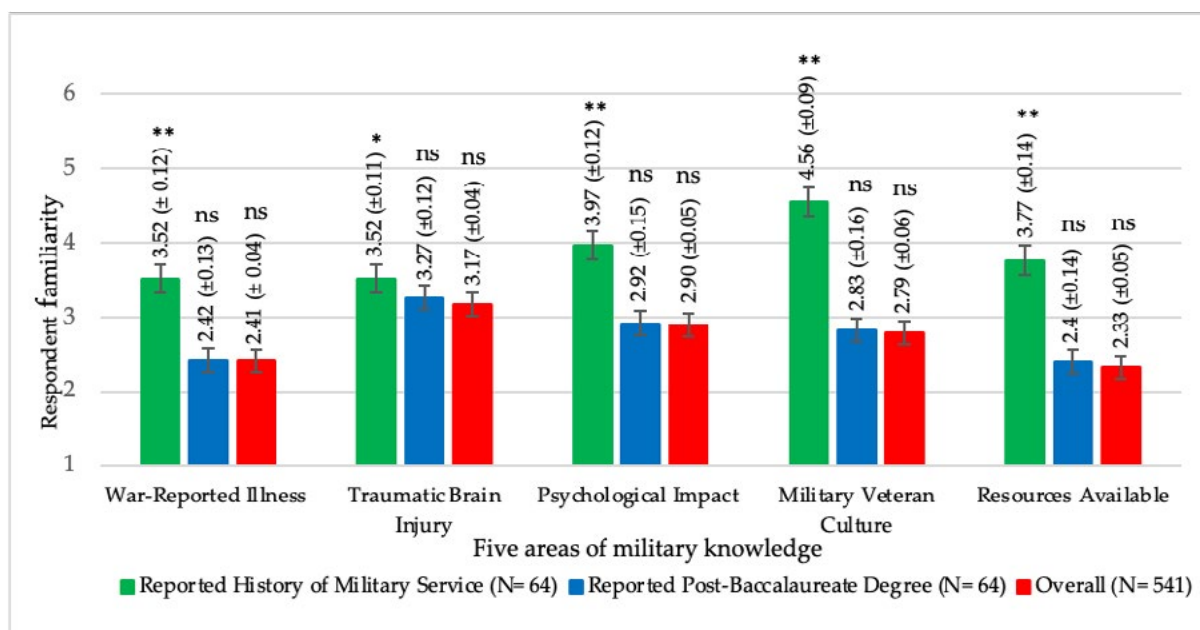
The items in the 'knowledge and competencies' domain (Q10) were internally consistent (standardised Cronbach's alpha = 0.84) and unidimensional, with the first eigenvalue for the reduced correlation matrix of 2.8 being considerably larger than the next value of 0.24. Factor loadings for the first principal component were similar (military veteran culture = 0.50, resources available = 0.48, war-related injury = 0.48, and psychologic impact = 0.46), except for the lower value of 0.29 associated with traumatic brain injury. However, since omitting the latter competency only increased the standardised Cronbach's alpha by a fractional amount (0.04), we opted to retain all the factors for this domain when presenting our analysis (in line with the original validation of this instrument).

Responses varied on current level of knowledge and preparedness of post-9/11 veterans among respondents that reported being 'very to extremely familiar'. Approximately 35% indicated traumatic brain injuries (mean = 3.2; SE = 0.04), 28% psychological impacts of war (mean = 2.9; SE = 0.05), 27% military/veteran culture (mean = 2.8; SE = 0.06), 15% military/veteran resources available (mean = 2.3; SE = 0.05), and 12% war-related illnesses (mean = 2.4; SE = 0.04) (Figure 1).

When nurses with a history of military service were compared with nurses without a history of military service significant differences for war-related illness, psychological impacts of war, military and veteran culture, and resources available were observed, independent of age and sex ( $p < 0.001$ ). The effect was less significant for traumatic brain injuries ( $p = 0.014$ ). It was expected that military veterans would have a higher level of familiarity owing to lived experiences. In contrast, there was no statistically significant difference in all five competencies between nurses who obtained a post-baccalaureate degree(s) and those without a post-baccalaureate degree.



Figure 1. Respondents' self-reported familiarity with post-9/11 veteran topics.



P-values above indicated bars provide comparisons with respective reference groups (e.g., no reported history of military service and no reported post-baccalaureate degree), adjusting for age group and sex (restricted maximum likelihood, fixed-effects model). Error bars indicate standard error. \* $p < 0.05$ , \*\* $p < 0.001$ , and ns = not significant.

### Surface-level knowledge

The correct answers to the definitive knowledge items were as follows: Q11.1 (FALSE): 7057 have died in combat or from combat-related injuries, while over 5116 have committed suicide while on active duty and over 30 177 have committed suicide following military service;<sup>44,45</sup> Q11.2 (FALSE): While many have served in a combat zone, no more than 10% have been engaged in combat;<sup>46</sup> Q11.3 (FALSE): As of 2018, only 38.9% of post-9/11 veterans had ever received care within the VA. The majority did not utilise external healthcare in the community;<sup>47-50</sup> Q11.4 (FALSE): Approximately 14% of post-9/11 veterans have screened positive for PTSD, whereas ~17% (520 966) have been diagnosed with cancer.<sup>51,52</sup> Q11.7 (TRUE): The median age is 38 as of 2022.<sup>50,53</sup>

More veteran vs non-veterans respondents accurately answered the non-distractor knowledge questions (i.e., age-group adjusted RR > 1.0), except for Q11.1 (Table 2). Significant differences were noted for veterans responding to Q11.3 (male: age-group adjusted RR = 1.9,  $P_{LRT} = 0.019$ ; female: age-group adjusted RR = 1.4,  $P_{LRT} = 0.023$ ; combined: age-group and sex adjusted RR = 1.4,  $P_{LRT} = 0.0015$ , not shown in table), Q11.4 (combined: unadjusted RR = 2.6,  $P_{LRT} = 0.027$ , not shown in table), and Q11.7 (males only: age-group adjusted RR = 1.3,  $P_{LRT}$

= 0.022). No significant knowledge differences were observed for respondents with a post-baccalaureate vs no post-baccalaureate degree. All 'Male x Female' interactions for veteran and post-baccalaureate degree knowledge questions were insignificant (except for post-baccalaureate degree Q11.4, which was indeterminate).

A composite knowledge score was created by summing the individual definitive knowledge questions. Overall, veteran respondents (mean = 3.3, SE = 0.01) had a significantly higher composite knowledge score than non-veteran respondents (mean = 2.8, SE = 0.04)  $p = 0.011$  (Table 3). Although the mean difference was significant, Cronbach's alpha value corresponding to the questions in this domain was only 17%, likely reflecting the diffuse nature of the dichotomous items. The composite knowledge score for respondents with a post-baccalaureate degree (mean = 2.9, SE = 0.13) did not significantly differ from those without a post-baccalaureate degree (mean = 2.9, SE = 0.04;  $p = 0.69$ ).

Male vs female veteran respondents were more likely to answer false to distractor question Q11.5, asking if more post-9/11 veterans experienced mental health concerns than Vietnam Veterans (male: aRR = 0.54,  $P_{LRT} = 0.0036$ ; female: aRR = 0.99,  $P_{LRT} = 0.95$ ;  $P_{INT} = 0.018$ ) (Table 4). The other distractor questions

**Table 2. Percentage of respondents accurately answering knowledge questions by sex (N = 541)**

Knowledge question	Profile	Male (n = 78)				Female (n = 463)				P <sub>Int</sub>
		Accurate		aRR	Accurate		aRR			
		Yes   No n (%)		PLRT	Yes   No n (%)		PLRT			
Q11.1† More post-9/11 veterans have died in combat than by suicide	Veteran								0.58	
	Yes	26 (39)	4 (36)	0.95	23 (6)	11 (10)	88			
	No	41 (61)	7 (64)	0.59	334 (94)	95 (90)	0.26			
	Post-Bac									
	Yes	5 (7)	1 (9)	1.1	44 (12)	14 (13)	0.95	0.17		
	No	62 (93)	10 (91)	0.65	313 (88)	92 (87)	0.53			
Q11.2† Most post-9/11 service members who have deployed have been involved in combat	Veteran							0.74		
	Yes	27 (40)	3 (27)	1.1	26 (8)	8 (6)	1.2			
	No	40 (60)	8 (73)	0.30	301 (92)	128 (94)	0.23			
	Post-Bac									
	Yes	5 (7)	1 (9)	0.99	40 (12)	18 (13)	0.97		0.91	
	No	62 (93)	10 (91)	0.96	287 (88)	118 (87)	0.71			
Q11.3† A majority of post-9/11 veterans use the Veterans Affairs hospitals and clinics for most healthcare needs and services	Veteran							0.84		
	Yes	26 (46)	4 (18)	1.3	23 (10)	11 (5)	1.4			
	No	30 (54)	18 (82)	0.019	210 (90)	219 (95)	0.023			
	Post-Bac									
	Yes	6 (11)	0 (0)	1.3	30 (13)	28 (13)	0.99		0.35	
	No	50 (89)	22 (100)	0.16	203 (87)	202 (88)	0.96			
Q11.4† More post-9/11 veterans have been diagnosed with post-traumatic stress than cancer	Veteran							0.63		
	Yes	6 (60)	24 (35)	2.4	2 (10)	32 (7)	1.5			
	No	4 (40)	44 (65)	0.18	19 (90)	410 (93)	0.62			
	Post-Bac									
	Yes	0 (0)	6 (9)	---	2 (10)	56 (13)	0.56		---	
	No	10 (100)	62 (91)		19 (90)	386 (87)	0.39			
Q11.7 Most post-9/11 veterans are under the age of 40 years old	Veteran							0.12		
	Yes	27 (46)	3 (16)	1.3	28 (8)	6 (7)	1.1			
	No	32 (54)	16 (84)	0.022	345 (92)	84 (93)	0.54			
	Post-Bac									
	Yes	5 (8)	1 (5)	1.2	48 (13)	10 (11)	1.1		0.15	
	No	54 (92)	18 (95)	0.35	325 (87)	80 (89)	0.24			

†Question is reverse coded (False). \*Indeterminate. aRR = Age-group adjusted relative risk (estimated by log-binomial regression model). Bac = Baccalaureate. Ind = Indeterminate. Int = Interaction. LRT = Likelihood ratio test.

**Table 3. Comparison of respondent composite knowledge scores (N = 541)**

Profile	Composite knowledge‡ Mean ± SE	P-value†
Veteran		0.011
Yes	3.3 ± 0.13	
No	2.8 ± 0.04	
Post-Baccalaureate		0.69
Yes	2.9 ± 0.13	
No	2.9 ± 0.04	

‡Composite knowledge scores were computed as the sum of Q11.1, Q11.2, Q11.3, Q11.4, and Q11.7. †Fixed-effects model adjusted for age-group and sex. SE = Standard error.

**Table 4. Percentage of respondents responding to distractor knowledge questions by sex (N = 541)**

Distractor knowledge question	Profile	Male (n = 78)		Female (n = 463)		P <sub>Int</sub>		
		Response		Response				
		True   False n (%)	aRR PLRT	True   False n (%)	aRR PLRT			
Q11.5 Post-9/11 veterans are more likely to experience mental health concerns than Vietnam Veterans	Veteran							
	Yes	12 (27)	18 (55)	0.54	24 (7)	10 (7)	0.99	0.018
	No	33 (73)	15 (45)	0.0036	298 (93)	131 (93)	0.95	
	Post-Bac							
Yes	3 (7)	3 (9)	0.80	44 (14)	14 (10)	1.1	0.40	
	No	42 (93)	30 (91)	0.55	278 (86)	127 (90)	0.13	
Q11.6 Vietnam Veterans are more likely to be diagnosed with cancer than post-9/11 veterans	Veteran							
	Yes	24 (41)	6 (30)	1.0	26 (7)	8 (8)	0.98	0.79
	No	34 (59)	14 (70)	0.88	339 (93)	90 (92)	0.79	
	Post-Bac							
Yes	3 (5)	3 (15)	0.57	40 (11)	18 (18)	0.87	0.30	
	No	55 (95)	17 (85)	0.11	325 (89)	80 (82)	0.24	

aRR = Age-group adjusted relative risk (estimated by log-binomial regression model). Bac = Baccalaureate.

Int = Interaction. LRT = Likelihood ratio test.

for veterans and post-baccalaureate degree holders were not significant, with no interactions being observed by sex.

### Practice assumptions and self-awareness

Nearly all the respondents (94%) stated they did not feel concerned or worried for their safety when caring for veterans (Q12.1), while almost half (43%) believe most veterans have had thoughts of suicide or are actively suicidal (Q12.2). When the nurses were asked if 'veteran status' changes how they provide a patient's care (Q12.3), 84% stated that status did not impact care processes. Approximately three-quarters (72%) believed that veterans experience psychosomatic symptoms related to mental health concerns (Q12.4). Over half (62%) thought that most veterans returned from combat physically fit and overall healthy (Q12.5). The standardised Cronbach's alpha score for Q12.1 through Q12.5 was 11%, suggesting only moderate to low consistency for these dichotomously coded items.

### Additional questions

Approximately 62% reported feeling either 'somewhat comfortable to extremely comfortable' in providing accurate, competent, holistic care to post-9/11 veterans through individualised screenings, assessments, or treatments (Q13). Seventy per cent of respondents reported cancer diagnoses ranging

between 50 to 69 years. These findings are slightly less than those reported by the National Cancer Institutes (SEER) Program, citing a median cancer diagnosis of 66 years.<sup>16</sup>

### State-level data

Every state except for West Virginia and Vermont was represented in the survey. California (14%), Massachusetts (6.7%), Texas (6.5%), Florida (5.7%), New York (4.6%), Arizona (3.9%) and North Carolina (3.8%) were the most frequently reported states of practice (Table 5). However, the percentage of survey respondents and the number of VA medical centres per practice state were not uniformly distributed. Similarly, the percentage of respondents in each state and the corresponding percentage of nurses in their respective state of practice differed. California had the greatest percentage of respondents and the highest number of VA medical centres (n = 9) but was home to few post-9/11 veterans (0.83%). On the other hand, only 0.68% of respondents practiced in Massachusetts, yet the state had four VA medical centres. Both Texas (1.2%) and Florida (1.1%) had a reasonable representation of post-9/11 veterans, relative to the number of VA medical centres in each state (7 and 8, respectively).

Mental health (Q9) was the most frequently reported issue for post-9/11 veterans, averaging 94% (SE = 1.5) across the indicated states in Table 5, except

**Table 5. Population statistics and survey responses by primary practice states having the highest percentage of respondents (N = 541)**

Characteristic AZ	Selected Primary Practice State											
	CA	FL	IL	IN	MA	NC	NY	PA	RI	TX	WA	
Population statistics												
% Post-9/11 veterans	1.1	0.83	1.1	0.82	1.1	0.68	1.3	0.61	0.90	1.1	1.2	1.4
% Registered nurses (RNs)	2.0	9.2	6.9	4.3	2.4	2.0	0.33	2.9	0.54	1.5	0.79	2.3
No. VA medical centers	3	9	8	5	1	4	4	3	7	1	7	3
Survey responses												
% Respondents	3.9	14	5.7	2.8	2.4	6.7	3.8	4.6	3.3	2.6	6.5	3.0
Q9 Most frequent issue for post-9/11 Veterans (%)*												
1. Mental health	90	89	94	100	100	94	100	100	83	93	91	94
2. Physical injury	0	1	0	0	0	3	0	0	6	0	0	0
3. Medical illness	10	9	6	0	0	3	0	0	11	7	9	6
Q10 Self-reported familiarity (Mean)†												
1. War-reported illness	2.1	2.5	2.2	2.7	2.1	2.6	2.7	2.6	2.6	2.2	2.4	2.3
2. Traumatic brain injury	2.9	3.4	3.2	3.3	3.0	3.2	3.3	3.2	3.1	2.9	3.2	3.0
3. Psychological impact	2.9	3.1	2.9	3.1	2.8	2.9	3.1	2.8	3.0	3.3	2.9	2.4
4. Military veteran culture	3.0	3.0	2.7	2.9	2.8	2.8	2.9	3.0	2.9	2.8	2.8	2.4
5. Resources available	2.5	2.5	2.1	2.7	2.4	2.3	2.5	2.3	2.6	2.6	2.1	2.2
Q11 Definitive knowledge questions answered accurately (%)												
1. More post-9/11 veterans have died in combat than by suicide	76	79	88	93	77	86	67	72	78	64	77	69
2. Most post-9/11 service members who have deployed have been involved in combat	52	71	81	80	62	69	81	80	72	79	74	75
3. A majority of post-9/11 veterans use the VA hospital clinics for most health care needs/services	62	56	55	67	46	33	38	56	72	64	40	69
4. More post-9/11 veterans have been diagnosed with post-traumatic stress than cancer	0	3	10	7	8	8	0	0	11	7	11	0
7. Most post-9/11 veterans are under the age of 40 years old	86	76	77	80	69	89	86	88	78	93	77	81
Q13 I feel competent and comfortable in providing thorough assessments, treatments, and care to post-9/11 veterans (Mean)‡	3.5	3.9	4.0	4.1	3.5	3.8	3.9	3.9	4.0	3.7	3.6	3.4

\*Mutually exclusive. †Likert scale (1 = Completely unfamiliar, 2 = A little bit familiar, 3 = Moderately familiar 4 = Very familiar, 5 = Extremely familiar). ‡Likert scale (1 = Extremely uncomfortable, 2 = Somewhat uncomfortable, 3) Neither comfortable nor uncomfortable, 4) Somewhat comfortable, 5) Extremely comfortable.



for Pennsylvania (83%). Physical injury and medical illness were sparsely reported, with means of 0.83% (SE = 0.53) and 5.5% (SE = 1.3), respectively.

The current level of knowledge and preparedness (Q10) varied across the five domains (war-related illness, traumatic brain injury, psychological impact, military veteran culture and resources available), with Illinois (Mean = 2.9, SE = 0.12) having the highest and Washington (Mean = 2.5, SE = 0.14) the lowest composite, self-reported familiarity scores. Across the indicated states, 'traumatic brain injury' had the highest composite score (Mean = 3.1, SE = 0.05), with California (Mean = 3.4 SE = 0.11) having the highest individual score within this domain. In contrast, 'resources available' had the lowest composite score across states (Mean = 2.4, SE = 0.06), with Florida (Mean = 2.1, SE = 0.21) having the lowest individual score within this domain.

Illinois had the highest composite mean score of 65% (SE = 15) for correctly answering the five definitive knowledge questions (Q11), compared with Indiana, which had the lowest score (Mean % = 52, SE = 12). Across the indicated states, few participants (Mean % = 5.4, SE = 2.3) were able to correctly answer that more post-9/11 veterans have been diagnosed with cancer than post-traumatic stress disorder (Q11.4). This contrasted with a mean % of 8.2 (SE = 2.0) for correctly answering that more post-9/11 veterans are under the age of 40 years (Q11.7). A mean % score of 55 (SE = 3.7) was observed for affirmatively answering that most post-9/11 veterans use VA hospitals and clinics for most health concerns/services (Q11.3).

Participants practicing in Florida indicated being the most comfortable and competent at diagnosing, treating and caring for post-9/11 veterans (Mean = 4.1, SE = 0.25), while Washington state had the lowest mean score of 3.4 (SE = 0.22).

### Discussion

Veterans share a unique culture and common values that influence their behaviour. Even after serving, veterans are still influenced by this culture and values that make it important for healthcare providers to understand so they can better serve this population. It is essential to listen to veteran's unique stories and avoid making assumptions about their individual experiences. Furthermore, asking questions, showing concern, building trust, understanding trauma and thanking veterans for their service with sincerity are all important considerations when working with veterans in healthcare settings.<sup>54</sup>

As the care for many post-9/11 veterans has transitioned to the civilian sector in recent years, we expressed concern that registered and advanced practice nurse professionals working outside of the VA system may not be fully prepared to provide knowledgeable and culturally competent healthcare for the distinct needs of post-9/11 veterans.<sup>7</sup> A key purpose of the current manuscript was to assess this potential practice gap, with the ultimate goal of improving the quality of health services provided to veterans in this setting.

Our findings suggest that few nurses employed in the civilian, non-VHA setting have ideal knowledge or understanding of post-9/11 military veteran-related risk factors and healthcare concerns. While most non-VHA nurses believe that post-9/11 veterans' health issues are predominantly related to mental health, post-traumatic stress and suicidality, this precludes attention to other significant health conditions. Survey respondents were divided between whether post-9/11 veterans use the VHA for most of their medical care or if they seek non-VHA care. The majority indicated limited knowledge of resources available to veteran patients in addition to risks of potential war-related illnesses and culture. Interestingly, a greater percentage of veteran respondents answered false to the distractor question Q11.5 (stating that more post-9/11 veterans experience more mental health concerns than Vietnam Veterans), suggesting this to be a potential area needing further research and explanation.

If mental health diagnoses or history of traumatic experiences in post-9/11 veterans leads providers to believe psychological conditions are the most frequently occurring and most expected conditions in practice, this may bias health outcomes. The potential for misdiagnosed or unidentified medical illnesses or malignancies and diagnostic errors with mental health conditions points to provider cognitive biases (i.e., illnesses are mistakenly minimised or ignored because of preconceived notions of prevalent mental health diagnoses in this population). These beliefs may be a result of an unconscious bias towards veterans. Essential ways to address this concern can involve education and training. VHA medical facilities across the US offer healthcare providers training to increase awareness of one's own unconscious bias towards veterans; however, it is unclear if non-VHA healthcare facilities offer similar training.<sup>55</sup>

Provider anchoring (aka 'the anchoring effect') occurs when the providers' decision is influenced by a particular reference point or 'anchor'. In this case, civilian providers may base a diagnosis on an initial

impression despite evidence pointing to the contrary. This may lead to a delay in care.<sup>56</sup> For example, a post-9/11 veteran who seeks care for persistent shortness of breath and chest pain may be seen as an otherwise healthy, non-smoking individual under the age of 40 with a mental health anchor diagnosis.

Implicit or unconscious bias by providers is another consideration. A norm is to attribute certain qualities to an entire group or cohort that an individual belongs to and is applied widely as a generalisation across individuals within that group.<sup>57</sup> In this setting, the assumption is that post-9/11 veterans have related mental health conditions and their assessment, diagnoses and treatment are based on that attribution. Given a lack of preventive screening, inaccurate assessments and a paucity of individualised 'veteran-focused' care in non-VHA settings, further evidence-based interventions are warranted to ameliorate the situation.

Knowledgeable frontline nurses are pivotal medical care providers, especially for veterans who are at risk because of their military-related exposures. They have been considered the most trusted profession in the US for the past 20 years based on their honesty and ethical standards, surpassing other providers by ~20%.<sup>58</sup> These highly skilled professionals conduct health assessments, gather historical information, coordinate care and interact more with patients in many settings than any other provider or care team member. As the VHA faces budgetary constraints and provider shortages, longer driving distances and wait times will further propel veterans to seek services within their community through the VA MISSION and PACT Acts.

Many VHA facilities across the US are in urban versus rural areas, emphasising that the location of VHA facilities should not be overlooked. This further reinforces the barrier that living in a rural area can place on an individual accessing healthcare. The need for more VHA facilities to adequately meet the needs of post 9/11 veterans, especially in rural areas, is another driving force for veterans to seek care in non-VHA facilities.<sup>59</sup> As this priority population grows civilian-based nurses must be appropriately trained in diagnosing and caring for veterans.

Unlike our positive findings for survey respondents who were veterans, there was no significant difference among those with a post-baccalaureate degree(s) versus those without. This highlights that post-baccalaureate degree(s) do not guarantee competence with military-related knowledge and veterans' healthcare needs, and more appropriate training may be necessary.

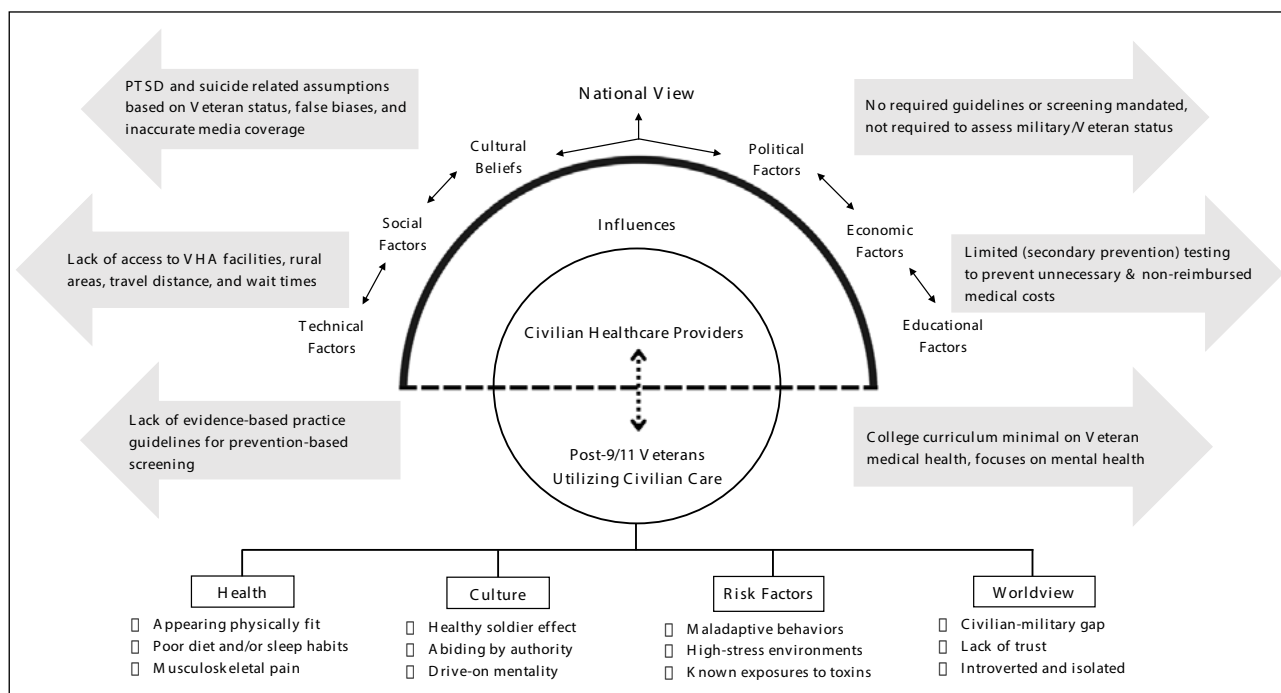
The Joining Forces Campaign was created when the Director of the Connecticut VHA teamed up with the American Academy of Nursing and Dr Jill Biden.<sup>60</sup> This joint effort requests that non-VHA providers ask patients the fundamental question, 'Have you ever served in the military?'. The intent is to facilitate communication between patients and providers, to identify risk factors related to veterans' health and promote individualised medical care. While non-VHA nurses generally wish to attend to the needs of veterans, many feel inadequately prepared and ill-informed to provide appropriate holistic care based on our survey findings. Despite the call for providers to inquire about military service history, many veterans are not being asked about their service-related background in non-VHA care settings.<sup>61</sup> Nurses cannot be expected to provide assessments, treatments and care based on information they do not know, so evidence-based, multimodal and interactive training specific to post-9/11 veterans is imperative.

Premised on Leininger's transcultural model for cultural care, there are six structural dimensional barriers governing the holistic, competent, and individualised care for veterans in the non-VHA setting (i.e., cultural beliefs, technical, social, political, economic and educational factors) (Figure 2).<sup>62</sup> Questions in our survey targeted these dimensions to provide ideas for constructive improvements. Cultural beliefs related to ill-informed, inaccurate media coverage and fictional portrayals in films perpetuate stereotypical beliefs about post-9/11 veterans. When asked where post-9/11 veterans receive most of their care, social factors were divided among nurse respondents. While some surmised that most use VHA services, others thought veterans accessed community care.

Actionable items and advanced practice population nursing recommendations include:

- a. Enacting an evidence-based curriculum for undergraduate and graduate nursing students and healthcare providers focusing on post-9/11 veteran risk factors and health issues.
- b. Advocating for development and access to cost-free, continuing education credits (CEU) for specified veteran health-related topics and requiring nurses to participate in licensure and renewal.
- c. Forming academic partnerships with the VHA to train students in veteran-centric clinical settings, which can be applied to non-VHA healthcare.

**Figure 2: Adaptation of Leininger’s Sunrise Model**



- d. Identifying the most at-risk states (e.g., using data collected on region size, amount of post-9/11 veteran residents, and average distances to VHA and non-VHA medical centres) and enacting guidelines by severity ranking to influence informed policymaking.
- e. Conducting studies involving nurses identifying provider-related factors associated with positive health outcomes in the post-9/11 veteran population.

**Limitations**

The information provided herein is best interpreted considering several limitations. Surveys are subjective and may not capture the complete picture of a complex topic. Recall, investigator, regional biases and the selectivity of respondents are important factors potentially impacting the validity of this survey. The organisation administering the survey and the intent of the questions asked were not blinded. Internal consistency and unidimensionality were only established for items in the ‘knowledge and competencies’ domain.

Exposures were not uniform during the Global War on Terror, and every veteran has a unique individual health profile related to their location of deployment. Upon return from deployment veterans may be more likely to reside near the base they were deployed from. Battalions and companies from the same

states often were deployed to different locations with different inherent health risks. While the analysis lacks granularity, the manuscript is an important first step to more detailed assessments of this topic. We do not believe these limitations influence the conclusions, with most biases towards the null.

Nurse participants completing our survey were not randomly selected and may not necessarily reflect the broader population of nurses working in a particular state. However, given that the survey focused on non-VHA veteran care we anticipated that the percentage of respondents would not reflect the proportion of nurses practicing in their respective states. That is, voluntary response bias could have been present in our sample, given that respondents may have been more likely to practice in non-VHA hospitals that serve veterans. Our survey did not include referent participants practicing in VHA healthcare facilities, thus precluding a comparison with the latter group.

The number of VA medical centres listed in Table 5 by state also did not include community-based outpatient clinics and ‘Vet’ centres. For example, Massachusetts has 14 outpatient clinics and seven Vet centres. While outpatient clinics are not hospitals, like the four other medical centres in Massachusetts, they provide primary and mental healthcare services to veterans. In contrast, Vet centres are non-medical settings that provide no-cost help to veterans and their families. This includes counselling and stress management services for PTSD and military sexual

trauma. Excluding outpatient clinics and Vet centres in Table 5 could be considered an undercount of services provided to veterans; however, in this exploratory overview, we wanted to focus on larger-scaled medical facilities that offer a broad range of specialties, including emergency and surgical departments.

Our survey, being conducted by a veteran-run non-profit organisation, was able to engage with participants who otherwise may not have responded to a survey sent from other organisations (i.e., Veterans Affairs or the Department of Defense). While participants may have been more inclined to respond, we cannot rule out conformity bias.

Lastly, the results of this analysis must be carefully interpreted, considering the large number of comparisons and the potential for multiplicity bias.

## Conclusions

Nurses are at the forefront of evaluating the specific medical needs of veterans receiving care in the non-VHA/civilian sector, especially in the post-9/11 era. They are well positioned to advocate for interventions and promote positive outcomes for this often-underserved population. The results of our survey indicate that the majority of nurses practicing in non-VHA settings believe that mental health is the most commonly occurring condition among post-9/11 veterans. This potentially neglects attention to other commonly occurring conditions that may present as lifelong challenges to post-9/11 veterans. As seen among veterans from previous wars, it still holds true that veterans' healthcare needs may peek decades after their deployment and service.<sup>63</sup>

Demographically, the number of veterans who receive care in non-VHA settings is expected to grow. Nurses must be prepared to provide evidence-based care and demonstrate high levels of knowledge and competency for this at-risk population. As the Post-Deployment Integrated Care Initiative notes, 'The most important action a provider can take to ensure that a veteran receives optimal care is perhaps the easiest and, ironically, the most neglected: asking if a patient has served in the military and taking a basic military history'.<sup>64</sup>

While our findings have important implications for nurse training, policy and practice, they also are relevant to physicians and other medical practitioners.

**Author contributions:** Conceptualisation: CS, JC, LB, JR and SK; survey curation: CS, JC and JR; formal analysis: CS, JR, CJ, KC and JTE; writing,

review and editing: CS, JC, LB, JR, PM, CJ, KC, YC, SK and JTE. The corresponding author attests that all listed authors meet the authorship criteria and that no others meeting the criteria have been omitted. The corresponding author further affirms that the manuscript is an honest, accurate and transparent work.

**Funding:** None.

**Institutional review board statement:** Approval was granted by the HunterSeven Foundation Ethics Review Committee (#HS-0231Z) and the Rhode Island College Institutional Review Board (#2122-2247).

**Informed consent statement:** This project meets exempt human subjects research criteria Category 4, and an informed consent form is not applicable.

**Disclaimer:** The views and opinions expressed in this article are those of the authors and do not necessarily reflect those of their respective institutions or the United States Government.

**Data availability statement:** Available by request.

**Acknowledgments:** We kindly thank Terri Tanielian, Veterans Affairs Special Assistant to President Biden, who led the RAND study and Dr Carrie M. Farmer (RAND Corporation) for permission to adapt the 'Ready or Not' web-based tool. Additionally, we acknowledge Cynthia Hau (VA Boston) for technical assistance.

**Conflicts of interest:** The authors have no conflict of interest to disclose.

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Appendix A

Adopted survey instrument

Question	Choice Selection
Q1. Are you trained and licensed as a registered nurse (RN, APRN, FNP, DNP, etc.)	Yes / No
Q1a. Do you work directly with, or provide care to patients as part of your regular professional activities?	Yes / No
Q1b. Which best describes your highest level of education?	Associate Degree Bachelor Degree Master Degree Doctoral Degree
Q2. Please tell us which best describes your practice setting.	Emergency Department Mental Health Acute Care (in patient) Case Management Oncology Intensive Care Surgical Primary Care Leadership / Education
Q3. Are you employed?	Full time (≥ 32 hours) Part time (< 32 hours) Per Diem
Q4. Gender at birth:	Male Female
Q5. Which state do you currently practice in?	[Free text]
Q6. Please select your age range (years):	< 20 20-29 30-39 40-49 50-59 60-69 >70+
Q7. Have you ever served in the United States Armed Forces (this includes the Army, Navy, Air Force, Marine Corps, and National Guard / Reserves)?	Yes / No
Q7a. If yes, please indicate how long (in years) you served in the military.	[Free text - numerical]
Q8. Do you have any close family members who currently or formerly served in the United States Armed Forces?	Yes / No
Q9. Based on your experience, what issue do you believe is occurring most frequently in the post-9/11 veteran population?	Mental Health Physical Injury Medical Illness
Q10. Using the [Likert scale], please rate your current level of knowledge and preparedness regarding the following topics pertaining to post-9/11 veterans: Q10.1 War-related illness Q10.2 Traumatic brain injury Q10.3 Psychological impacts of war Q10.4 Military and veteran culture Q10.5 Resources available	Completely unfamiliar (1) A little bit familiar (2) Moderately familiar (3) Very familiar (4) Extremely familiar (5)

Q11. Please select 'true' or 'false' for each question pertaining to post-9/11 veteran knowledge.	True / False
Q11.1 More post-9/11 veterans have died in combat than by suicide.	
Q11.2 Most post-9/11 service members who have deployed have been involved in combat.	
Q11.3 A majority of post-9/11 veterans use the Veterans Affairs hospitals and clinics for most healthcare needs and services.	
Q11.4 More post-9/11 veterans have been diagnosed with post-traumatic stress than cancer.	
Q11.5 Post-9/11 veterans are more likely to experience mental health concerns than Vietnam Veterans.	
Q11.6 Vietnam Veterans are more likely to be diagnosed with cancer than post-9/11 veterans.	
Q11.7 Most post-9/11 veterans are under the age of 40 years old.	
Q12. Please select 'true' or 'false' for each question based on your beliefs about post-9/11 veterans.	True / False
Q12.1 When caring for veterans, I worry about my physical safety.	
Q12.2 The majority of veterans are suicidal and have had thoughts of suicide.	
Q12.3 A patient's veteran status changes how I provide overall care.	
Q12.4 I believe veterans experience many psychosomatic symptoms related to mental health.	
Q12.5 I believe veterans returning from combat are physically fit and overall healthy.	
Q13. I feel competent and comfortable in providing thorough assessments, treatments, and care to post-9/11 veterans.	Extremely uncomfortable (1) Somewhat uncomfortable (2) Neither comfortable nor uncomfortable (3) Somewhat comfortable (4) Extremely comfortable (5)
Q14. In my opinion and based on my personal clinical experiences, the average age range (years) of patients diagnosed with cancer is?	<20 20-29 30-39 40-49 50-59 60-69 70-79 ≥ 80

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# Incidences and Trends of Cardiovascular Determinants and Diagnoses in Active Duty Service Members

S R Vincent, M A Schlenk, K A Horan, B A Moore

## Abstract

Obesity, alcohol use and hypertension place military service members at a greater risk of developing cardiovascular disease (CVD). The current study utilised the Defense Medical Epidemiology Database (DMED) data to conduct a retrospective cohort study on the incidence rate trends of CVD and six risk factors (per 10 000) in active duty service members from 2016 to 2021. The average incidence rates of CVD diagnoses in active service members decreased except for angina. Specifically, aortic aneurysm and tear, atherosclerosis, peripheral vascular disease (PVD), stroke and heart attack incidence rates decreased (-31.94%, -29.91%, -19.58%, -9.36%, and -3.49%, respectively). However, incidence rates of angina increased by 14.77%. When examining CVD and risk factors, the incidence rate of inappropriate diet increased (54.58%). The remaining risk factors, such as diagnoses of overweight/obesity, diabetes mellitus (types 1 & 2), hypertension, high cholesterol and tobacco use (-21.42, -39.31%, -30.08%, -24.41%, and -36.85%, respectively) decreased between the years 2016 and 2021. The decrease in incidence rates of CVD warrants further investigation into the explanations for this decline. The large overrepresentation of specific demographics signals a warranted need to increase screening efforts for those at increased risk.

**Keywords:** Cardiovascular disease, military, active duty service members, risk factors

## Cardiovascular disease

The leading cause of death in the United States is cardiovascular disease (CVD),<sup>1</sup> characterised by a group of illnesses associated with the heart or blood vessels (2). The categories of CVD are coronary heart disease, cerebrovascular disease, peripheral arterial disease, deep vein thrombosis, and pulmonary embolism.<sup>2</sup> Coronary heart disease, cerebrovascular disease and peripheral arterial disease are diseases of the blood vessels supplying the heart, brain, arms and legs, respectively.<sup>2</sup> Deep vein thrombosis is blood clots from the legs dislodging and moving towards the heart and lungs.<sup>2</sup> One aspect that precedes CVD diagnosis is poor cardiovascular health.

## Cardiovascular health

Poor cardiovascular health not only heightens the risk of developing CVD but also impacts life expectancy.<sup>3</sup> In the general population, common factors that influence CVH include blood pressure, cholesterol, fasting plasma blood glucose, physical activity, diet, smoking and body mass index (BMI).<sup>4</sup>

Many conditions can play a role in moderating the severity of cardiovascular health. These risk factors are sorted into different classifications, such as modifiable, nonmodifiable, exogenous and endogenous.<sup>5</sup> These categories include genetic, occupational, environmental and behavioural factors. This study primarily focuses on behavioural risk factors such as physical inactivity, tobacco use, alcohol consumption and poor diet.<sup>2</sup>

## Cardiovascular health and disease in the military

Cardiovascular disease impacts the general population in addition to active duty service members.<sup>6</sup> This disease negatively affects service members' physical health mission readiness, and contributes to low job productivity,<sup>7</sup> thereby placing more lives at risk due to the inability to perform their duties.<sup>8</sup>

In addition to health concerns highlighted among the general population, military service members may encounter unique occupational stressors (i.e., poor

living conditions<sup>9</sup> and combat exposure<sup>10</sup>), which are associated with increased cardiac diagnoses. For example, a study of 8727 traumatically injured service members showed that they were more likely to develop hypertension, diabetes and coronary artery disease when compared to uninjured patients.<sup>9</sup> Additionally, posttraumatic stress disorder (PTSD) diagnoses have been significantly associated with CVD<sup>10</sup> and drastically increased in the post-9/11 environment.<sup>11</sup>

With respect to risk factors, US Army personnel exhibit other risk factors and worsening CVH, such as unhealthy blood pressure<sup>12</sup> and increased smoking use compared to civilians.<sup>12,13</sup> This is concerning as a report from the Department of Defense identified that approximately 13% of service members above the age of 20 are obese and only 24.7% were a 'heathy weight',<sup>14</sup> decreasing military readiness and increasing their likelihood of discharge,<sup>15</sup> thereby increasing immediate and long-term care costs. Therefore, the primary aim of this study is to examine the incidence rates of CVD diagnoses and behavioural risk factors. A secondary objective is to investigate which categories of service members are most at risk of diagnoses for CVD or behavioural risk factors.

## Method

The current report is a retrospective cohort-based study utilising the Defense Medical Epidemiology Database (DMED) data. This publicly available database uses the International Classification of Disease ten (ICD-10) codes. In the present study, we used ICD-10 codes used for atherosclerosis (I70, I25.1, I25.81, I25.7), heart attack (I21), stroke (I63), aortic aneurysm and tear (I71), peripheral vascular disease (PVD, I73.89, I73.9) and angina (I20) for all service members between 2016 and 2021. Additionally, the ICD-10 codes utilised for overweight/obesity (E66), hypertension (I10), type 1 diabetes mellitus (E10), type 2 diabetes mellitus (E11), high cholesterol (E78.0, E78.1, E78.2, E78.5), tobacco use (Z72.0), and inappropriate diet and eating habits (Z72.4). The diagnostic criteria for inappropriate diet and eating habits are not explicitly stated; however, the ICD code excludes eating disorders, lack of adequate food and malnutrition. It also excludes any socioeconomic or life management difficulty related to poor eating habits.<sup>16</sup>

## Variables

The demographics included in the DMED dataset contained service members' branch (Army, Marines, Air Force and Navy), sex (male, female), marital

status (married, nonmarried), age (<20, 20–24, 25–29, 30–34, 35–39, >40), rank (junior enlisted, senior enlisted, junior warrant/commissioned officers and senior commissioned officers) and race (White, Black, Other). Space Force data was not included due to its recency of establishment. Coast Guard data was not included in the dataset due to their alignment with the Department of Homeland Security rather than their full-time assignment to the Department of Defense.

## Statistical analysis

This report calculated incidence rates per 10 000 service members for each CVD diagnosis and known risk factors for active duty service members between 2016 and 2021. Additionally, the single sample chi-square analyses examined any significant differences between expected and observed CVD diagnoses and risk factor among demographic groups. Expected and observed cases are relative to population density rather than normative clinical expectations. Moreover, we calculated standardised residuals for each demographic group to contextualise the significance of the differences. Finally, we calculated the percentage change in CVD diagnoses and associated risk factors from 2016 to 2021.

## Results

### Representativeness by demographic variables

Between the years of 2016 and 2021, the largest density of active duty service members were between the ages of 20–24 (32%), male (83%), junior enlisted (43%), white (69%), married (52%), and serving in the Army (36%). Tables 1 to 4 present the demographic outcomes of each demographic variable.

Except for angina, the average incidence rates of CVD in active service members between 2016 and 2021 decreased. Specifically, aortic aneurysm and tear, atherosclerosis, PVD, stroke and heart attack incidence rates decreased (-31.94%, -29.91%, -19.58%, -9.36%, and -3.49%, respectively). Incidence rates of angina increased by 14.77%. The full range of incidence rates and diagnosis changes are in Tables 1 to 4. When examining risk factors, the incidence rate of inappropriate diet increased (54.58%), with those diagnoses most commonly occurring in the Navy. However, the remaining risk factors, such as overweight/obesity, diabetes mellitus (types 1 & 2), hypertension, high cholesterol and tobacco use (-21.42%, -39.31%, -30.08%, -24.41%, and -36.85%, respectively) decreased between the years 2016 and 2021.

## Sex

Except for angina, chi-square analyses presented significant ( $p < 0.001$ ) differences between CVD and risk factor diagnoses by sex. Males presented with fewer cases than expected when examining overweight/obesity diagnoses ( $S/R = -34.38$ ), but overrepresentation in the incidence of high cholesterol ( $S/R = 22.27$ ). In comparison, females presented with fewer diagnoses of hypertension and high cholesterol than expected ( $S/R = -30.64$ ,  $S/R = -53.00$ , respectively). Females presented with more cases than expected in overweight/obesity ( $S/R = 81.84$ ) diagnoses. Additional information is available in Tables 1 to 4.

## Age

Significant ( $p < 0.001$ ) differences between CVD and risk factor diagnoses were observed when examining age groups. Service members within the age group of  $>40$  presented with more cases than expected in atherosclerosis, angina, PVD and aortic tear and aneurysm ( $S/R = 133.79$ ,  $S/R = 53.95$ ,  $S/R = 30.67$ ,  $S/R = 43.97$ , respectively). Similarly, this trend held for diabetes, hypertension, and high cholesterol ( $S/R = 126.77$ ,  $S/R = 242.29$ ,  $S/R = 307.90$ , respectively). All service members within the age groups of  $<20$  and  $20-24$  presented fewer cases for all CVD and most risk factors than expected ( $S/R$ s ranging between  $-1.42$  and  $-139.83$ ). Additional information is available in Tables 1 to 4.

## Marital status

Significant differences ( $p < 0.001$ ) between CVD and risk factors diagnoses were observed when examining marital status. All service members categorised as married presented with more cases for all of the CVD diagnoses than expected ( $S/R$ s ranging between  $13.0$  [angina] and  $47.01$  [atherosclerosis]). Married service members were significantly overrepresented in hypertension and high cholesterol ( $S/R = 146.93$ ,  $S/R = 158.12$ , respectively)—unmarried service members presented with fewer cases of both CVD ( $S/R$ s ranging between  $-12.77$  [PVD] and  $-41.67$  [atherosclerosis]) and risk factors ( $S/R$ s ranging between  $-2.99$  [inappropriate diet] and  $-140.16$  [high cholesterol]) than expected. With regard to the evaluation of risk factors, the greatest values consisted of unmarried service members with hypertension and high cholesterol ( $S/R = -130.24$ ,  $S/R = -140.16$ , respectively). Additional information is available in Tables 1 to 4.

## Race

There were significant differences ( $p < 0.05$ ) between CVD and risk factors diagnosis by race. White service members were underrepresented in incidence rates of diabetes, hypertension and overweight/obesity ( $S/R = -32.40$ ,  $S/R = -47.17$ ,  $S/R = -10.23$ , respectively) than expected. Black service members presented with more diagnoses of diabetes, hypertension and overweight/obesity ( $S/R = 47.74$ ,  $S/R = 82.61$ ,  $S/R = 25.21$ , respectively) than expected. Additional information is available in Tables 1 to 4.

## Rank

Significant ( $p < 0.001$ ) differences between CVD and risk factor diagnoses were observed. When examining rank, service members classified as junior enlisted and warrant and commissioned officers were underrepresented among all CVD diagnoses and a few risk factors. Specifically, junior enlisted presented with fewer cases than expected in hypertension and high cholesterol ( $S/R = -129.99$ ,  $S/R = -150.10$ , respectively). Conversely, non-commissioned and senior commissioned officers were overrepresented in all CVD diagnoses. Senior enlisted and senior officers presented with more cases than expected among hypertension ( $S/R = 99.15$ ,  $S/R = 93.63$ , respectively) and high cholesterol diagnoses ( $S/R = 80.29$ ,  $S/R = 176.84$ , respectively). Non-commissioned officers presented more diagnoses than expected in all the risk factors except inappropriate diet ( $S/R = -0.71$ ). Additional data is available in Tables 1 to 4.

## Service branch

Chi-square analyses exhibited significant ( $p < 0.001$ ) differences between CVD and risk factor diagnosis by branch. Service members in the Army were overrepresented for diagnoses of hypertension, tobacco use, high cholesterol, diabetes and overweight/obesity ( $S/R = 20.13$ ,  $S/R = 15.81$ ,  $S/R = 18.22$ ,  $S/R = 6.27$ ,  $S/R = 33.23$ , respectively). Service members in the Navy presented with more diagnoses than expected for diabetes ( $S/R = 19.98$ ). Service members in the Air Force had a higher number of diagnoses of angina than expected ( $S/R = 15.34$ ). Marines presented with fewer diagnoses than expected for diabetes, hypertension and high cholesterol ( $S/R = -26.23$ ,  $S/R = -51.51$ ,  $S/R = -55.57$ , respectively). Additional data is available in Tables 1 to 4.



**Table 1. Demographics of service members with CVD and CVD risk factors with an increasing incidence between 2016 and 2021**

Demographics	Military density	Angina N = 5300 ICD-10 (I20)		Inappropriate diet N = 1322 ICD-10 (Z72.4)	
		IR	S/R	IR	S/R
Overall incidence (per 10,000)		6.75		1.68	
% Change from 2016 to 2021		14.77%		54.58%	
<b>Sex</b>		$X^2(1, 5300) = .78$ $p = 0.376$		$X^2(1, 1322) = 366.95$ ; $p < 0.001^{**}$	
Female	17%	6.24	0.82	3.43	17.66
Male	83%	6.85	-0.34	1.34	-7.41
<b>Age, years</b>		$X^2(5, 5300) = 3731.78$ $p < 0.001^{**}$		$X^2(5, 1322) = 19.91$ ; $p = 0.001^*$	
< 20	7%	2.29	-10.39	1.61	1.55
20-24	32%	3.48	-20.15	1.58	-1.42
25-29	23%	4.04	-14.12	1.54	-1.55
30-34	16%	6.00	-1.87	1.53	-0.66
35-39	12%	9.85	10.24	1.86	0.77
40+	10%	24.80	53.95	2.47	3.47
<b>Marital status</b>		$X^2(1, 5300) = 1379.08$ $p < 0.001^{**}$		$X^2(1, 1322) = 20.29$ ; $p < 0.001^{**}$	
Married	52%	9.06	27.79	1.63	3.37
Nonmarried	48%	14.77	-24.63	3.69	-2.99
<b>Race/Ethnicity</b>		$X^2(2, 5300) = 175.28$ $p < 0.001^{**}$		$X^2(2, 1322) = 7.12$ ; $p = 0.029^*$	
White	69%	6.02	-6.91	1.61	-1.40
Black	17%	9.06	10.73	1.90	2.15
Other	14%	7.46	3.52	1.73	0.73
<b>Service branch</b>		$X^2(3, 5300) = 393.48$ $p < .001^{**}$		$X^2(3, 1322) = 54.01$ ; $p < .001^{**}$	
Army	36%	7.31	0.07	1.49	-3.99
Navy	25%	4.66	-8.56	2.08	5.96
Air Force	25%	9.38	15.34	1.67	0.43
Marine Corps	14%	4.46	-9.21	1.49	-1.55
<b>Military pay grade</b>		$X^2(3, 5300) = 1035.54$ $p < .001^{**}$		$X^2(3, 1322) = 30.27$ ; $p < .001^{**}$	
Jr. Enlisted	43%	3.85	-19.75	1.83	2.65
Sr. Enlisted	39%	9.40	14.84	1.73	-0.71
Jr. Officer	11%	4.35	-5.87	0.85	-4.71
Sr. Officer	7%	14.06	19.77	1.84	0.74

Note: Military composition percentages provided by the DMED. 'Jr. Enlisted' includes pay grades E-1 to E-4; 'Sr. Enlisted' includes pay grades E-5 to E-9; 'Jr. Officer' includes pay grades O1/W1-O3/W3; 'Sr. Officer' includes pay grades O4/W4-O9/W5. The DMED provides marital status as Married, Single or Other. As there is no way to meaningfully discriminate between 'single' or 'other', this variable was dichotomised to improve interpretation. DMED data above represents the incidence rate change between 2016 and 2021. \*Indicates significance at  $p < 0.001^{**}$

Abbreviation: DMED = Defense Medical Epidemiology Database; IR = Incidence Rate; S/R = Standardised residuals

**Table 2. Demographics of service members with CVD and risk factors with a decreasing incidence rate between 2016 and 2021**

Demographics	Military density	Cerebrovascular infarction		PVD		Myocardial infarction	
		N = 2734 ICD-10 (163)		N = 1436 ICD-10 (173.89, 173.9)		N = 2200 ICD-10 (I21)	
		IR	S/R	IR	S/R	IR	S/R
Overall incidence (per 10 000)		3.48		1.83		2.80	
% Change from 2016 to 2021		-9.63%		-19.58%		-3.49%	
<b>Sex</b>		$X^2(1, 2734) = 61.91;$ $p < 0.001^{**}$		$X^2(1, 1436) = 88.93;$ $p < 0.001^{**}$		$X^2(1, 2200) = 84.55;$ $p < 0.001^{**}$	
Female	17%	4.28	7.25	2.64	8.69	1.35	-8.48
Male	83%	3.33	-3.05	1.67	-3.65	3.09	3.56
<b>Age, years</b>		$X^2(5, 2734) = 1726.39;$ $p < 0.001^{**}$		$X^2(5, 1436) = 1240.49;$ $p < 0.001^{**}$		$X^2(5, 2200) = 1912.33;$ $p < 0.001^{**}$	
< 20	7%	0.83	-9.07	0.46	-6.43	0.81	-7.47
20–24	32%	1.50	-17.05	0.74	-12.96	1.28	-14.55
25–29	23%	2.15	-9.65	1.17	-6.66	1.49	-10.58
30–34	16%	3.77	2.79	1.62	-1.06	2.36	-2.10
35–39	12%	6.20	12.94	2.87	6.74	4.66	9.82
40+	10%	11.45	32.94	7.13	30.67	10.91	37.84
<b>Marital status</b>		$X^2(1, 2734) = 746.19;$ $p < 0.001^{**}$		$X^2(1, 1436) = 370.77;$ $p < 0.001^{**}$		$X^2(1, 2200) = 704.55;$ $p < 0.001^{**}$	
Married	52%	4.71	20.44	2.45	14.41	3.91	19.86
Nonmarried	48%	7.87	-18.12	4.24	-12.77	5.69	-17.61
<b>Race/Ethnicity</b>		$X^2(2, 2734) = 45.33;$ $p < 0.001^{**}$		$X^2(2, 1436) = 20.14;$ $p < 0.001^{**}$		$X^2(2, 2200) = 219.63;$ $p < 0.001^{**}$	
White	69%	3.30	-2.59	1.75	-1.68	2.32	-7.03
Black	17%	4.42	6.13	2.28	4.09	4.63	12.98
Other	14%	3.23	-1.01	1.69	-0.78	2.95	1.31
<b>Service branch</b>		$X^2(3, 2734) = 43.26;$ $p < 0.001^{**}$		$X^2(3, 1436) = 75.75;$ $p < 0.001^{**}$		$X^2(3, 2200) = 86.78;$ $p < 0.001^{**}$	
Army	36%	3.66	-0.96	2.23	3.08	3.50	4.54
Navy	25%	3.51	2.72	1.33	-3.76	2.65	0.76
Air Force	25%	3.74	2.61	2.19	4.22	2.69	-0.35
Marine Corps	14%	2.53	-5.31	1.07	-5.85	1.51	-8.09
<b>Military pay grade</b>		$X^2(3, 2734) = 675.96;$ $p < 0.001^{**}$		$X^2(3, 1436) = 502.73;$ $p < 0.001^{**}$		$X^2(3, 2200) = 483.51;$ $p < 0.001^{**}$	
Jr. Enlisted	43%	1.73	-16.72	0.81	-13.53	1.47	-14.22
Sr. Enlisted	39%	4.84	10.52	2.50	7.11	4.12	11.72
Jr. Officer	11%	2.87	-0.86	1.58	-0.09	1.78	-3.95
Sr. Officer	7%	7.69	16.88	4.97	16.40	5.51	11.33

Note: Military composition percentages provided by the DMED. ‘Jr. Enlisted’ includes pay grades E-1 to E-4; ‘Sr. Enlisted’ includes pay grades E-5 to E-9; ‘Jr. Officer’ includes pay grades O1/W1-O3/W3; ‘Sr. Officer’ includes pay grades O4/W4-O9/W5. The DMED provides marital status as Married, Single or Other. As there is no way to meaningfully discriminate between ‘single’ or ‘other’, this variable was dichotomised to improve interpretation. DMED data above represents the incidence rate change between 2016 and 2021. \*Indicates significance at  $p < 0.001^{**}$

Abbreviation: DMED = Defense Medical Epidemiology Database; PVD = Peripheral Vascular Disease; IR = Incidence Rate; S/R = Standardized Residuals

**Table 3. Demographics of service members with CVD and risk factors of moderate incidence rate decreases between 2016 and 2021**

Demographics	Military density	AAD N = 1259		Atherosclerosis N = 6955		High cholesterol N = 78195		Overweight/Obesity N = 51824	
		ICD-10 (I71)		ICD-10 (I70, I25.1, I25.81, I25.7)		ICD-10 (E78.0-E78.2, E78.5)		ICD-10 (E66)	
		IR	S/R	IR	S/R	IR	S/R	IR	S/R
Overall incidence (per 10 000)		1.61		8.88		99.77		66.17	
% Change from 2016 to 2021		-31.94%		-29.91%		-24.41%		-21.42%	
<b>Sex</b>		X <sup>2</sup> (1, 1259) = 48.12; p = < 0.001**		X <sup>2</sup> (1, 6955) = 203.00; p = < 0.001**		X <sup>2</sup> (1, 78195) = 3305.04; p = < 0.001**		X <sup>2</sup> (1, 51824) = 7879.16; p = < 0.001**	
Female	17%	0.78	-6.40	4.78	-13.14	45.91	-53.00	115.95	81.84
Male	83%	1.77	2.69	9.69	5.52	110.41	22.27	56.35	-34.38
<b>Age, years</b>		X <sup>2</sup> (5, 1259) = 2397.75; p = < 0.001**		X <sup>2</sup> (5, 6955) = 20985.42; p = < 0.001**		X <sup>2</sup> (5, 78195) = 137556.69; p = < 0.001**		X <sup>2</sup> (5, 51824) = 709.75; p = < 0.001**	
< 20	7%	0.22	-7.25	0.89	-18.00	2.90	-66.37	32.70	-21.98
20–24	32%	0.34	-16.01	1.57	-39.08	12.10	-139.83	65.68	-2.21
25–29	23%	0.59	-10.85	2.23	-30.12	37.74	-83.89	65.64	-1.13
30–34	16%	1.35	-1.58	4.24	-16.14	85.92	-10.14	64.62	2.55
35–39	12%	2.49	5.94	11.86	8.20	218.68	107.96	81.24	14.08
40+	10%	8.58	43.97	58.52	133.79	487.07	307.90	79.00	3.95
<b>Marital status</b>		X <sup>2</sup> (1, 1259) = 531.35 p < 0.001**		X <sup>2</sup> (1, 6955) = 3946.73; p = < 0.001**		X <sup>2</sup> (1, 78195) = 44648.86; p = < 0.001**		X <sup>2</sup> (1, 51824) = 4406.69; p = < 0.001**	
Married	52%	2.36	17.25	13.92	47.01	156.83	158.12	74.53	49.68
Nonmarried	48%	3.20	-15.29	16.26	-41.67	175.60	-140.16	140.13	-44.03
<b>Race/Ethnicity</b>		X <sup>2</sup> (2, 1259) = 10.58; p = 0.005*		X <sup>2</sup> (2, 6955) = 53.47; p = < 0.001**		X <sup>2</sup> (2, 78195) = 1366.58; p = < 0.001**		X <sup>2</sup> (2, 51824) = 765.66; p = < 0.001**	
White	69%	1.72	1.81	8.52	-3.33	96.30	-9.87	63.09	-10.23
Black	17%	1.36	-2.12	9.00	0.86	89.21	-10.90	82.93	25.21
Other	14%	1.37	-1.68	10.45	6.45	129.00	33.92	60.73	-5.06
<b>Service branch</b>		X <sup>2</sup> (3, 1259) = 28.22; p = < 0.001**		X <sup>2</sup> (3, 6955) = 222.12; p = < 0.001**		X <sup>2</sup> (3, 78195) = 3847.45; p = < 0.001**		X <sup>2</sup> (3, 51824) = 2363.44; p = < 0.001**	
Army	36%	1.85	1.44	11.14	8.42	118.96	18.22	88.15	33.23
Navy	25%	1.63	1.85	7.78	-1.54	90.01	-1.44	46.96	-24.02
Air Force	25%	1.57	-0.01	8.68	0.09	111.91	20.62	50.11	-24.89
Marine Corps	14%	1.03	-4.77	5.38	-12.20	46.63	-55.57	71.96	7.91
<b>Military pay grade</b>		X <sup>2</sup> (3, 1259) = 1434.81; p = < 0.001**		X <sup>2</sup> (3, 6955) = 9765.08; p = < 0.001**		X <sup>2</sup> (3, 18897) = 60222.12; p = < 0.001**		X <sup>2</sup> (3, 51824) = 1791.95; p = < 0.001**	
Jr. Enlisted	43%	0.44	-16.67	1.83	-42.80	17.10	-150.10	73.20	19.38
Sr. Enlisted	39%	1.97	3.53	11.37	11.14	152.73	80.29	71.76	3.59
Jr. Officer	11%	1.32	-0.65	5.62	-7.03	86.92	0.22	31.03	-32.48
Sr. Officer	7%	7.65	33.82	45.73	88.09	348.69	176.84	45.99	-18.66

Note: Military composition percentages provided by the DMED. 'Jr. Enlisted' includes pay grades E-1 to E-4; 'Sr. Enlisted' includes pay grades E-5 to E-9; 'Jr. Officer' includes pay grades O1/W1-O3/W3; 'Sr. Officer' includes pay grades O4/W4-O9/W5. The DMED provides marital status as Married, Single or Other. As there is no way to meaningfully discriminate between 'single' or 'other', this variable was dichotomised to improve interpretation. DMED data above represents the incidence rate change between 2016 and 2021. \*Indicates significance at p = < 0.05\*; p = < 0.001\*\*

Abbreviation: AAD = Aortic aneurysm and dissection; DMED = Defense Medical Epidemiology Database; IR = Incidence Rate; S/R = Standardized Residuals

**Table 4. Demographics of service members with CVD and CVD risk factors with large decreasing incidence between 2016 and 2021**

Demographics	Military density	Diabetes mellitus (1 & 2) N = 13010 ICD-10 (E10,E11)		Hypertension N = 106493 ICD-10 (I10)		Tobacco use N = 21624 ICD-10 (Z72.0)	
		IR	S/R	IR	S/R	IR	S/R
Overall incidence (per 10 000)		16.63		136.21		27.65	
% Change from 2016 to 2021		-39.31%		-39.08%		-36.85%	
<b>Sex</b>		$X^2(1, 13010) = 25.71$ ; $p < 0.001^{**}$		$X^2(1, 106493) = 1104.17$ ; $p < 0.001^{**}$		$X^2(1, 21624) = 182.63$ ; $p < 0.001^{**}$	
Female	17%	13.55	-4.67	94.19	-30.64	19.76	5.23
Male	83%	17.24	1.96	144.49	12.87	29.22	-12.46
<b>Age, years</b>		$X^2(5, 13010) = 20821.01$ ; $p < 0.001^{**}$		$X^2(5, 106493) = 95054.95$ ; $p < 0.001^{**}$		$X^2(5, 21624) = 1145.17$ ; $p < 0.001^{**}$	
< 20	7%	2.66	-22.49	12.11	-71.50	10.41	-19.43
20–24	32%	4.58	-47.13	40.42	-130.86	22.81	-15.33
25–29	23%	6.90	-32.17	82.78	-61.74	28.02	0.76
30–34	16%	11.56	-11.78	144.87	15.61	32.88	14.58
35–39	12%	30.10	29.21	267.83	100.30	38.66	17.36
40+	10%	81.02	126.77	495.13	242.29	33.93	4.22
<b>Marital status</b>		$X^2(1, 13010) = 5108.14$ ; $p < 0.001^{**}$		$X^2(1, 106493) = 38550.66$ ; $p < 0.001^{**}$		$X^2(1, 21624) = 2481.80$ ; $p < 0.001^{**}$	
Married	52%	23.95	53.48	192.97	146.93	32.27	37.28
Nonmarried	48%	34.87	-47.41	286.66	-130.24	61.54	-33.05
<b>Race/Ethnicity</b>		$X^2(2, 13010) = 3702.57$ ; $p < 0.001^{**}$		$X^2(2, 106493) = 9236.03$ ; $p < 0.001^{**}$		$X^2(2, 21624) = 189.32$ ; $p < 0.001^{**}$	
White	69%	11.04	-32.40	113.44	-47.17	29.62	7.56
Black	17%	33.08	47.74	217.24	82.61	22.87	-9.85
Other	14%	23.52	19.32	147.41	13.68	24.02	-5.93
<b>Service branch</b>		$X^2(3, 13010) = 1182.99$ ; $p < 0.001^{**}$		$X^2(3, 106493) = 3154.54$ ; $p < 0.001^{**}$		$X^2(3, 21624) = 481.68$ ; $p < 0.001^{**}$	
Army	36%	19.51	6.27	161.37	20.13	34.94	15.81
Navy	25%	20.71	19.98	130.17	7.56	24.86	-1.08
Air Force	25%	14.06	-7.52	138.56	6.28	22.65	-11.64
Marine Corps	14%	6.37	-26.23	78.25	-51.51	22.62	-9.75
<b>Military pay grade</b>		$X^2(3, 13010) = 5562.09$ ; $p < 0.001^{**}$		$X^2(3, 106493) = 35622.01$ ; $p < 0.001^{**}$		$X^2(3, 21624) = 2147.07$ ; $p < 0.001^{**}$	
Jr. Enlisted	43%	5.29	-50.01	51.54	-129.99	24.46	-9.01
Sr. Enlisted	39%	27.81	42.28	212.77	99.15	38.75	30.36
Jr. Officer	11%	9.90	-11.14	105.15	-11.25	11.05	-24.63
Sr. Officer	7%	36.30	33.90	291.77	93.63	11.00	-23.18

Note: Military composition percentages provided by the DMED. 'Jr. Enlisted' includes pay grades E-1 to E-4; 'Sr. Enlisted' includes pay grades E-5 to E-9; 'Jr. Officer' includes pay grades O1/W1-O3/W3; 'Sr. Officer' includes pay grades O4/W4-O9/W5. The DMED provides marital status as Married, Single or Other. As there is no way to meaningfully discriminate between 'single' or 'other', this variable was dichotomised to improve interpretation. DMED data above represents the incidence rate change between 2016 and 2021. \*Indicates significance at  $p < 0.05$ ;  $p < 0.001^{**}$

Abbreviation: DMED = Defense Medical Epidemiology Database; IR = Incidence Rate; S/R = Standardized Residuals



## Discussion

This study examines the most prominent cardiovascular risk factors and diagnoses<sup>17</sup> in active duty service members between 2016 and 2021. To our knowledge, this is the first study to investigate incidence rates of cardiovascular health and diagnoses among US active duty service members across the largest service branches.

### Cardiovascular disease and demographics

The identified incidence of CVD decreased between 2016 and 2021, except for angina. A possible reason for this growth, when investigating the rise in angina, may be misdiagnosis. The main symptom of angina is chest pain.<sup>18</sup> However, it can also be present in different diseases and disorders. Therefore, a provider may attribute chest pain to angina instead of other medical problems with the same symptoms. For example, chest pain is a symptom when participating in strenuous activity. Most service members diagnosed with CVD are senior enlisted and senior commissioned officers, >40 years of age, black or married. One possible consideration is that older service members assigned sedentary tasks may be more likely to become physically inactive. Similarly, when progressing in rank, service members are not faced with physically strenuous jobs that require them to maintain a healthy diet and remain physically active. Finally, there is often a stigma associated with help-seeking behaviours in the service. Thus, it could be that older service members are waiting until they are closer to retirement to seek care. One recent report highlighted the racial gap in CVD death rates, where black Americans experienced 800 000 more cardiovascular-related deaths in comparison to the white American population.<sup>19</sup> Considering this, cultural or genetic components could contribute to the increased incidence of varied diagnoses.

### Cardiovascular health and demographics

With respect to behavioural risk factors, inappropriate diet diagnoses have increased over time. One study supports this increase based on its results reporting that only 29% of service members reported eating fruit once a day, and overall, only 3% met the Health People 2010 objectives for vegetables, fruits, and grains.<sup>20,21</sup> Concerning diabetes, a previous study on the incidence rates of type 2 diabetes in active duty between 2006 and 2015 found similar findings<sup>22</sup> as those reported here. The most overrepresented demographic was service members who were 40 or older.<sup>22</sup> Concerning obesity/overweight

diagnoses, the rate increased by 8% between 1995 and 2008.<sup>23</sup> The treatments of obesity<sup>24,25</sup> and the development of newly crafted interventions in the active service surrounding diet, physical activity, and weight management<sup>26</sup> may be a reason for the 21.42% decrease in the current study. Additional examination of the Army's holistic health and fitness program effectiveness in reducing CVD and risk factors may be warranted and, where appropriate, extended to other branches. Additionally, this program may benefit ageing service members by focusing on at-risk members through tailored CVD-relevant programming.

### Military implications

The higher-than-expected rates of risk factor diagnosis in the Army may be present due to the Army being the largest branch or increased access to care compared to other branches. One thing to note that warrants further investigation is the low incidence of inappropriate diet in comparison to the increased incidence of high cholesterol and overweight/obesity. Theoretically, all three diagnoses should fluctuate in unison. However, available diagnosis data implies that poor diet is underreported or, at a minimum, a secondary diagnosis that is not well captured. There may be underdiagnoses due to the lack of nutritionist or nutrition-related knowledge available to service members and leadership.<sup>27</sup>

### Limitations

This study encompassed the most common CVD diagnoses but did not include all potential CVD (i.e., rheumatic heart disease and arrhythmia). This created a limitation as to saying the results address all possible CVD. Second, the DMED data consists of de-identified group-level data provided for a single ICD code, thus preventing us from exploring comorbid conditions, symptoms and prior military experience. Additionally, we cannot definitively state which diagnostic criteria were used in each case, as any medical provider with access to a patient's electronic health record can input a diagnosis. Thus, we are unable to examine diagnoses in isolation. Therefore, the incidence rates may be higher than reported due to the cases of comorbid conditions excluded from the dataset. Finally, the healthy worker effect, a particular selection bias, can also play a role due to programs<sup>28</sup> that regulate physical health in the military, thereby increasing bias in the present sample.

## Strengths

The strengths of this study include the vastness of the data used. The data encompasses the four largest military branches; therefore, reports about the incidence of CVD and risk factors in the military can be broadly reported. Additionally, specific results on each demographic provide insights to better address certain groups most at risk of CVD and should be used to inform future interventions. Finally, the data consists of first-time diagnoses, eliminating the possibility of reoccurring diagnoses and impacts of simultaneous comorbidities.

## Conclusion

A retrospective cohort-based analysis was conducted using DMED data among active duty service members. There were decreases in CVD and the corresponding determinants, signalling the effectiveness of interventions in the military. Additionally, the analyses showed that specific demographics are overrepresented or unrepresented across various diagnoses. The findings necessitate an investigation into the reasons for the decline and continuing implementation of the interventions

impacting CVD among service members, as well as investigating strategies to lessen incidence rates of preceding risk factors for CVD. These results highlight the importance of creating more tailored screening processes to ensure the proper diagnosis of CVD and the risk factors in overrepresented demographics. Future directions for this study consist of performing more detailed analyses with more comprehensive databases (i.e., the USARIEM SPHERE) to report the estimated risks of diagnoses for each demographic. Overall, these findings do not align with what is known regarding CVD and its risk factors in the general population. There is a consistent rise in CVD and most of its determinants in the general population.<sup>29</sup> With this rise, civilians should implement prevention interventions where feasible.

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# Hearing Health in the Australian Defence Force

Y L Chia

Loud, hazardous noise exposure is ubiquitous and unavoidable in the Defence Force. As a result, it has the unfortunate but foreseeable effect of inducing early-onset hearing loss and/or tinnitus among service members. In Australia, Australian Defence Force (ADF) members and veterans<sup>1</sup> can receive fully subsidised hearing care under the Commonwealth Hearing Services Program (HSP). While the HSP has its own limitations for the Defence/veteran community, as a clinical audiologist, this author has assisted numerous actively serving personnel and veterans through the HSP and is aware of the number of individuals who have benefited from this service.<sup>2</sup>

Currently, to access these hearing services, ADF members are first referred to an audiologist for the following reasons: (1) to confirm abnormal screening audiogram results; (2) to monitor known hearing loss; (3) to investigate clinical presentations of hearing difficulty, asymmetrical hearing loss and/or tinnitus; or (4) provision/management of hearing aids. While these are excellent trigger points for a referral, many members appear to be presenting at their audiology appointment, reporting years of untreated, long-standing hearing difficulties and/or severe, debilitating or intrusive tinnitus. Conversations with numerous ADF members and veterans have led this author to identify common reasons for why this is occurring:

1. The culture among Defence personnel of not wanting to appear 'weak' or 'letting their teams down' or having a health consideration that may limit postings and/or promotions. It is known that fitness-for-duty requirements can affect members' willingness to disclose hearing problems or the presence and/or impact of tinnitus on their personal and professional lives. At times, this under-reporting was allegedly supported by military medical officers. For this reason, many members may 'reverse malingering', with veterans later reporting that they have denied, concealed or trivialised their hearing

1 Gold Card and White Card (hearing specific conditions) holders.

2 For further reading, refer to article by Dr Russell Shute et al. (2023).<sup>8</sup>

symptoms to maintain their status or obtain special jobs.

*'I personally knew my hearing was deteriorating for several years, especially in my left ear so whenever I went for my annual hearing test, I would put the headphones on backwards when the left-ear beeps started. This allowed me to do the entire hearing test with my right ear, thereby appearing "normal". This was clearly not the smartest thing to do, but at the time, it seemed to be the only thing I could do not to risk my ongoing employment. I have seen countless others conceal injuries or illnesses for other similar reasons. With regards to tinnitus though, I have read how people in the past took drastic action to try to make it stop.'* –Veteran

*'People will not ask if it is normal to have a noise in your head and if there is any treatment. Saying you have a noise in your head suggests you have a mental health issue because the noise is not real. This then pulls into question your deployability, security clearance and career and financial stability.'* –Veteran

2. Misinformation or lack of knowledge regarding tinnitus across the Defence community – both among service members and across leadership, managerial and medical ranks.

*'When I first knew that the noise was called tinnitus in 2022, I was told nothing could be done to treat tinnitus. I've asked a heap of people since if they have tinnitus, and it seems to be quite prevalent, but there is misinformation either from medical officers or perpetuated within ranks that it is an issue that can't be alleviated or treated. There seems to be an urban legend that nothing can be done so it is not worth seeking at least alleviation of tinnitus when it is annoying you.'* –Veteran

*'It has even been put to me that not educating us on labelling or specifically asking if we hear a high-frequency noise in our ears was a way of evading the burden it would place on ADF medical to treat.'* –Veteran



*'When I first experienced "ringing in my ears", I didn't know what it was. When it became intrusive, I started reporting it at all my hearing screens and my annual Defence medicals. I was told it was tinnitus and that it was normal or fine. Action was not taken on it.'* –Veteran

3. Existing cultural challenges within Defence where stigma remains associated with 'help-seeking'. This may be particularly so for hearing-related issues which are 'invisible' and may not be socially condoned, justified or considered 'legitimate'. As quoted by a veteran,

*'Many won't seek treatment as it is embarrassing to whinge about a high-pitched noise when a mate has died of an IED blast, has a disfigurement or has lost a limb.'*

In addition, increasing research indicates that noise-induced damage can still occur without causing a detectable change in the audiogram.<sup>1</sup> This phenomenon is termed hidden hearing loss, an auditory dysfunction with the hallmarks of speech intelligibility deficits despite normal or near-normal hearing levels.<sup>2</sup> Aside from reduced speech clarity, hidden hearing loss can also contribute to tinnitus development and the acceleration of age-related hearing loss across the lifespan.<sup>3,4</sup> Anecdotally, ADF members and veterans who have presented with symptoms of 'hidden hearing loss' reported feeling inadequate, embarrassed and frustrated by their hearing inadequacies despite acing consecutive hearing screenings.

*'I felt stupid for constantly having to ask for repeats when I supposedly have normal hearing. In the end I just gave up listening at meetings and would later ask a colleague if I had missed anything important.'* –Active ADF member, exhibiting symptoms of hidden hearing loss.

As a result of the above, a vast majority of ADF members and veterans likely struggle with untreated auditory dysfunction<sup>3</sup> for many years. While hearing loss and tinnitus are not life-threatening conditions, it is the impact of suppressing, concealing and masking one or both of these conditions that is of greatest concern. Hearing loss compromises one's ability to communicate and, in turn, the ability to partake in daily activities, relate to others and deeply connect with people, both professionally and personally. Hearing loss can cause individuals to withdraw by

3 For the purposes of this article, auditory dysfunction refers to hearing loss and/or tinnitus

avoiding or tuning out at social events as it can be upsetting when everyone appears to be having a good time, yet, hearing difficulties prevent one from joining the conversation or catching the punchline of a joke. Although misunderstandings can sometimes be humorous, they can also be embarrassing, frustrating and disengaging when one's contribution does not align with the conversation. It is not unusual for veterans to report that their hearing loss, which has sometimes been concealed for decades, has led to conflict with family/friends, significant mental exhaustion, fatigue and feelings of loneliness, low self-confidence/self-worth and insecurity.

*'After running my own meetings or briefing senior committees on my multi-billion dollar project, I would be mentally exhausted from attempting to lip read or embarrassed by how many times I would ask for the question or answer to be repeated. Eventually, I really pushed to be referred to an audiologist in one of my annual Defence medicals and was able to be fitted with hearing aids through the Hearing Services Program. However, as they were Bluetooth enabled (as most hearing aids are these days), they were often not permitted to be worn within secure working spaces, compounding the exhaustion and embarrassment even further.'* –Ex-Senior Officer, medically retired May 2023.

While some ADF members adapt to their tinnitus over time, those who do not and are repeatedly reinforced by medical staff or colleagues that 'nothing can be done' may go on to experience other health comorbidities compounded by the perceived impact of their tinnitus and/or the hopelessness of the situation. This includes conditions such as depression, anxiety, sleep disorders, substance abuse and, in extreme cases, suicide. There is indeed significant evidence that psychological disorders that are paired with a hearing impairment, such as tinnitus, can exacerbate each other.<sup>5,6</sup> In the military arena, such consequences can impact on job performance and operational missions (ironically, the reason for concealing any hearing issues in the first place), which could be costly in terms of mission effectiveness and even survivability.<sup>7</sup>

According to the Department of Veterans' Affairs, hearing loss and tinnitus are two of the most common conditions experienced by former ADF members. However, of greater concern is the high and increasing number of claims for both conditions over the years (Table 1). These figures may not include veterans reluctant to seek help or talk about their tinnitus in their efforts to 'soldier on' and not complain.<sup>8</sup>

**Table 1: Percentage of sensorineural hearing loss and tinnitus claims accepted under the Military Rehabilitation and Compensation Act 2004.**<sup>9,10</sup>

Condition	Percentage of claims accepted under the MRCA (2004)		
	2014–2015	2019–2020	2021–2022
<b>Sensorineural hearing loss</b>	7.1%	11%	16.8%
	556 accepted claims	2,458 accepted claims	4,163 accepted claims
	90% acceptance rate	98.5% acceptance rate	99.2% acceptance rate
<b>Tinnitus</b>	9.1%	27%	18.2%
	710 accepted claims	5,935 accepted claims	4,526 accepted claims
	96% acceptance rate	96.3% acceptance rate	94.6% acceptance rate

While the ADF has come a long way in improving and providing hearing protection, there are many situations where hearing protection is impossible (e.g. during active combat) or impractical for continuous use. The unpredictability of gunfire and explosive detonations is also another factor that can catch an individual unprepared without hearing protection.

In light of this, it could be argued that the detection and mitigation of hearing loss must not only include effective noise control, hazard assessments and audiometric monitoring but for a hearing conservation program that aims to educate, train, identify, monitor and intervene.

The goals of such a program would be to:

1. Promote healthy hearing through adequate and relatable hearing education
2. Reduce the impact of occupational and, at times, unavoidable, loud noise exposure through timely and intentional hearing monitoring
3. Maintain fitness-for-duty and mission readiness of all personnel, including retention of skilled and experienced members in speciality jobs, through early intervention
4. Normalise the currently serving ADF members seeking help for hearing conditions so the requisite medical, audiological and management responses can be put into place.

### Hearing conservation program: A proposed framework

#### 1. Hearing loss prevention education

According to Beamer et al. (2020), 'If hearing protection is the cornerstone of hearing loss prevention, it is hearing health education that serves as the foundation for successful hearing loss prevention efforts' (p.685).<sup>7</sup> The authors added that without appropriate education, military personnel

are unaware of the harmful effects of noise on hearing, the impact of noise-induced hearing loss on job performance and daily living, how to correctly use hearing personal protective equipment (PPE) and hearing protection measures for off-duty noise-hazardous activities.

In August 2010, Safe Work Australia published a paper investigating the obstacles and enablers that play a role in effective noise control and hearing loss prevention.<sup>11</sup> Infrequent and improper use of hearing protectors, insufficient knowledge of the effects of loud noise, a belief that hearing loss 'will not happen to me' (optimism), low confidence about being able to do anything about noise (self-efficacy) and work cultures that are resistant to change were among the barriers identified by the study. The report's highly favoured recommendation was education. This sentiment was later echoed by Elsey & Jennings in 2014, who affirmed that 'a lack of understanding about a subject matter will not induce any action to be taken at the workplace'.<sup>12</sup>

Conversations between this author and ADF personnel/veterans indicate a desire for greater understanding and knowledge.

*'When I was first posted to a flying unit back in 2011, there was an element of raising awareness for the use of hearing PPE but long-term health effects of hearing loss/tinnitus were not discussed in detail on the course. From an aviation point of view, I would say the most effective time to raise awareness of the effects of hearing loss/tinnitus is at the delivery of said safety familiarisation courses.*  
–Active Defence Member

*I was, for example, told to wear hearing protection when things were noisy but no detail was ever given regarding the degree of protection to wear for different noises, how to wear it or how to even access it in many*

*cases. Additionally, I was never taught what would happen if I didn't do this other than not wearing it was "bad for you". Education is one thing, but the quality of that education and the acceptance of it is critically important, as is the tailoring of it to suit individual employment. Had the teaching been more explanatory, then I (and others) may have taken more care, as may many others.'* –Veteran

*'If I knew more about my hearing and the impact of hearing loss/tinnitus from the beginning, I would have 100% openly discussed it with medical staff. If more Defence members did this and actually reported through their workplaces, Defence would gain a better appreciation of how much this is actually affecting their workforce.'* –Veteran

*'Every year, we do mandatory training ranging from heat illness, records management, alcohol, equity and diversity and occasionally, a token form of mental health preservation. If we want to change the culture of hearing loss and mental health, it needs to be featured in our annual training and normalised within our management culture. Today, we are far from it.'* –Ex Senior officer, medically retired May 2023.

It would therefore seem prudent that the provision of hearing PPE be accompanied by information on the real and relatable risks of loud noise exposure and the real and relatable impact hearing loss and/or tinnitus can have on quality of life

A list of potential topics that could be considered in the planning of a hearing conservation program include, but are not limited to:

- How? Simplified explanation of how hearing works, the impact of loud noise on the auditory system, phenomenon of hidden hearing loss.
- Who? Noise-induced hearing loss does not discriminate by age, gender or health status.
- What? What might occur after noise exposure? What does 'cotton wool' hearing and 'ringing ears' mean? Recovery of symptoms does not mean no hearing damage.
- Why? Repeated noise exposure leads to irreversible damage through permanent hearing loss and/or tinnitus. Inclusion of a veteran with lived experience may be beneficial to 'strike at the core' of listeners and ensure information is memorable, believable and relevant.<sup>12</sup>

- When? When and how to use hearing protection and, more importantly, its fit and suitability (e.g. earmuffs are impossible to use in a confined space like performing maintenance under armoured vehicles). Training on how to care for, maintain and store hearing PPE.
- Where? Where to seek help or advice for defective hearing PPEs. There was a common theme among interviewed veterans of not knowing where to go or who to consult regarding this. Reduced accessibility reduces compliance.

Material sources could include technical guides, brochures, factsheets, websites, videos, in-person demonstrations, computer-based training and presentations for mobile device platforms. Participant satisfaction and feedback on educational materials should be solicited to improve the quality of material overtime. Longitudinal studies of learning effects should also be included in future research.

## 2. Timely and intentional hearing monitoring

Hearing screening should continue routinely, with perhaps an increased test frequency for those in higher noise exposure roles. Post-deployment hearing screenings should also be mandated promptly, with personnel screened for tinnitus and particular attention given to those with blast-related injuries/concussion, traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD). This is due to findings that auditory pathways are susceptible to injury and/or dysfunction after a TBI, with a higher proportion of veterans with comorbid TBI perceiving their tinnitus as 'very severe'.<sup>13</sup> Research also found that soldiers with blast-related injuries are twice as likely to develop hearing loss, with audiometric patterns varying from typical 'noise-induced audiograms'.<sup>14-17</sup> While one condition does not cause the other, tinnitus may exacerbate any pre-existing mental health symptoms, subsequently reducing an individual's overall coping abilities.<sup>18</sup> Research has found that even partial PTSD was associated with an increased incidence of tinnitus progression among a group of active-duty Marine and Navy personnel.<sup>17</sup>

Given what we know about hidden hearing loss, self-reported auditory problems should not be ignored despite the presence of a normal audiogram. To support this, blast-exposed US veterans were found to show significantly more hearing handicap and poorer central auditory processing than their non-blast-exposed peers despite presenting with 'normal hearing'.<sup>19</sup> The study showed that the reported hearing difficulties caused challenges in many environments where social interaction was necessary, which significantly impacted the emotional health of

these veterans.<sup>19</sup> More recently, a longitudinal study on the UK Armed Forces showed that self-reported hearing problems with tinnitus were associated with increased odds of mental health issues and alcohol misuse 7 years later.<sup>20</sup>

### 3. Early intervention as a preventative strategy

Misconceptions or the lack of knowledge about tinnitus are often reasons for developing a maladaptive response to the condition or the progression of its severity.<sup>21</sup> This was frequently observed among the Australian Veterans this author has seen, with the following anecdotal quotes obtained from veterans with significant tinnitus.

*'The only way I knew how to get relief from my tinnitus was to be around noise that was louder than my tinnitus. So I would intentionally work next to very loud sources of noise, like engines and stuff, to mask my tinnitus. I didn't realise that would only make it worse.'*

*'I didn't know what tinnitus was until I had it. "Present me" wishes I could go back to "past me" and say the ringing in your ears means you need to take your hearing more seriously.'*

*'We were told to have a drink (alcohol) at night if the tinnitus kept us from falling asleep. We were given no coping information. It would have helped if I knew more about it.'*

It would, therefore, appear reasonable to deduce that educating ADF members on their tinnitus and empowering them with basic self-management skills would be significantly beneficial. Research supports this and has shown that knowledge about tinnitus can facilitate habituation, mitigate severity levels and increase resilience towards the condition.<sup>22,23</sup> Similarly, a study investigating the impact of tinnitus on US Military Service members and veterans suggested that 'tinnitus should be addressed earlier in the military' to maximise functioning and quality of life among personnel.<sup>24</sup>

To cater to the time and operational constraints of the ADF, tinnitus education could be introduced as group sessions at ADF health centres and offered to personnel who experience persistent tinnitus, comorbid risk factors<sup>4</sup> or who would like to learn self-management strategies. These sessions could perhaps cover the foundations of tinnitus neurophysiology, basic cognitive coping skills, sound therapy benefits

4 Risk factors: traumatic brain injury, post-traumatic stress disorder, blast-related injuries and/or concussion.

and the greater importance of proper hearing protection, and provide an opportunity to problem-solve frequent hearing/tinnitus-related problems. Aside from information giving, a group construct may also foster a sense of social connectedness through the shared experience of an otherwise private and rarely discussed condition. Rather than playing the role of a patient, sufferer or, in some cases, victim, group attendees can assume the role of a proactive and coping individual.<sup>23</sup> Personnel continuing to struggle can then be fast-tracked or referred to an audiologist (under the HSP), tinnitus specialist, psychologist and/or tinnitus support group for further individualised treatment.

An example of group training has been observed at the Walter Reed National Military Medical Center in the United States. The centre has provided a modified version of Progressive Tinnitus Management (PTM) group education over the past 8 years. It includes two 2-hour group appointments and is available to active-duty members, veterans and their dependents. A recent retrospective assessment revealed that group education was effective and significantly reduced self-reported tinnitus awareness and annoyance two months post-session. The study also found that modifications to the content (greater emphasis on sound management vs cognitive education) had no significant effect on outcomes.<sup>22</sup> This suggests there can be some level of flexibility in the protocol.

### 4. Development of a safe climate/culture that would promote behavioural change

While not explored in detail, there remains an undercurrent of stigma associated with help-seeking among ADF members. Although scientific and medical advances are improving capabilities, stigma reduction will continue to act as a barrier to early preventative and stabilising care and must be prioritised and addressed.

*'The message that it is not weak to speak should be applied to all injuries, not just mental health because physical or sensory injuries untreated or poorly treated can be the last drop that breaks the surface tension and sends veterans to suicide.'* –Veteran

*'The ADF has all the policies, posters and polish that people are first and that it's not weak to speak up about physical or mental health considerations. The reality is that current culture suppresses speaking up about yourself or your subordinates due to a disproportionate volume of senior leaders being too focused on*



*themselves and painting a positive picture of everybody around them.* –Ex-Senior Officer, medically retired May 2023.

### Conclusion

Hearing loss and tinnitus are long-standing, service-connected disabilities for members of the ADF that not only prevail but appear to be on the rise. While mortality is not a direct consequence of auditory dysfunction, unidentified and untreated hearing loss and tinnitus can compound and exacerbate associated health conditions that burden the individual, their families and larger community. Given this, there is an urgent call for a well-rounded hearing conservation program to retain and rehabilitate serving ADF members and improve quality-of-life outcomes for those who dedicate themselves to protecting this nation.

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### Disclaimer

The views expressed in this article are those of the author and do not necessarily reflect the position of the Australian Defence Force, Department of Veterans' Affairs or the Australian Government.

### Acknowledgment

"Special thanks to the veterans and ADF members who contributed to this article and entrusted me with their experience. My thanks also to Canberra Audiology, Dr David Sly, Dr David Welch, Dr Neil Westphalen, Ben Campbell and Joanna Wilson for their support."

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# Measuring Dental Fear and Anxiety in New Zealand Defence Force Personnel

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## Abstract

**Background:** The widely-used Dental Anxiety Scale (DAS) has practical and theoretical limitations. The Index of Dental Anxiety and Fear (IDAF-4C) was developed to overcome these shortcomings but requires more psychometric analysis to determine its utility.

**Purpose:** To compare DAS and IDAF-4C validity and reliability among New Zealand Defence Force (NZDF) personnel.

**Material and methods:** A survey of NZDF recruits and officer cadets collected data on dental anxiety using the IDAF-4C, the DAS and a global dental anxiety item.

**Results:** Some 134 individuals completed the questionnaire. Confirmatory factor analysis for the IDAF-4C showed that a single factor explained 72.4% of the variance. The IDAF-4C showed high internal consistency reliability ( $\alpha = 0.94$ ). Confirmatory factor analysis for the DAS showed that a single factor explained 69.5% of the variance. The DAS showed high internal consistency reliability ( $\alpha = 0.85$ ). While the IDAF-4C showed a consistent gradient in mean scale scores across response categories of the global dental anxiety question, the gradient for the DAS was less consistent. The IDAF-4C and DAS showed considerable concordance ( $r = 0.71$ ).

**Conclusion:** The IDAF-4C demonstrated excellent psychometric properties, validity and reliability, and it is a valid and useful instrument for measuring dental anxiety and fear in Defence Force personnel.

**Keywords:** Dental anxiety; measurement scales; adults

## Introduction

Dental anxiety and fear are problems that are not fully understood due to their complex nature and aetiology. High dental anxiety and fear are associated with adverse psychosocial consequences such as lower self-esteem and morale.<sup>1</sup> It has been almost universally observed that dental anxiety and fear are more common among women than men.<sup>2-5</sup> Dental anxiety also negatively affects oral health and general wellbeing.<sup>6-8</sup> It is a major contributor to irregular dental attendance and prolonged avoidance of dental treatment.<sup>9</sup> Such avoidance is likely to result in poorer oral health, with people who are dentally fearful having (on average) more decayed surfaces, fewer restored teeth and more missing teeth than their non-dentally fearful counterparts.<sup>5,10</sup> This occurs through a vicious cycle of dental fear, whereby individuals with high dental fear are more likely to delay treatment. Such symptomatic visiting results in more invasive dental procedures that feed back and maintain or exacerbate the existing dental

fear.<sup>11</sup> Dental fear is also associated with a higher prevalence of toothache, being uncomfortable with the appearance of the mouth, teeth or dentures, and avoiding particular foods along with lower life satisfaction and trouble sleeping due to dental problems.<sup>11</sup>

Dental anxiety must be measured through self-report, but existing dental anxiety scales have their flaws, many of which arise from their inability to embrace contemporary understanding of dental anxiety aetiology.<sup>12</sup> Using different scales results in different prevalence estimates. The prevalence of dental anxiety has been reported to range from as low as 7.3% to as high as 28.4%, and an Australian study found a low degree of concordance among estimates using three existing measures.<sup>12</sup> A key issue when using a scale to measure dental anxiety is that the scales measure different constructs differently.<sup>12-13</sup> To date, the most extensively used scale has been the four-item Dental Anxiety Scale (DAS), on which an individual's score can range from

4 (least anxious) to 20 (most anxious).<sup>14</sup> A score of 13 or above classifies a person as 'dentally anxious'. The DAS has been criticised for the lack of a conceptual basis behind its development, the threshold score of 13 being wholly arbitrary, and its inability to adequately distinguish differing levels of dental anxiety (instead, it is more likely to identify high and low, but not moderate anxiety). Another flaw is that the items lack consistency, and the response options are neither mutually exclusive nor reflect dental anxiety using a scale in the ordinal manner required in such instruments.<sup>15</sup> Somewhat surprisingly for such a scale, the DAS does not refer to injections for local anaesthetic, which are known to be associated with dental fear.<sup>16</sup>

The Index of Dental Anxiety and Fear (IDAF) was developed to overcome such limitations.<sup>17</sup> It is based on theory and has three modules, which (respectively) measure dental anxiety and fear, dental phobia and feared dental stimuli. Armfield developed this approach to allow researchers and clinicians to use the module of interest while considering the different origins of dental fear and/or anxiety. The abbreviation IDAF-4C+ represents the modules comprising the index, which measures an individual's cognitive, emotional, behavioural and physiological components, while the '+' represents the added modules. The IDAF-4C is the core module determining the respondent's overall level of dental fear. This instrument comprises eight items, with two assessing each of those four components of anxiety and fear. Responses are collected using a 5-point Likert scale reflecting how strongly participants agree or disagree with an item. The responses are summed and then standardised by dividing the total score by the number of items, and a score of 3 or more defines someone as dentally anxious.<sup>17</sup>

Because there is no 'gold standard' dental anxiety scale, finding a reference point against which the validity of such a scale can be tested is challenging. Accordingly, the psychometric properties of this scale must be examined across a range of populations instead of basing it on a single set of observations.<sup>18</sup> The psychometric evaluation of the IDAF-4C has been undertaken in a smaller number of studies, mainly limited to Australia<sup>17</sup> and New Zealand.<sup>19</sup> The latter compared the psychometric properties of the IDAF-4C and the DAS. The IDAF-4C showed good evidence of validity in terms of the underlying factor structure and associations with dental service use. There was a moderate correlation (Pearson's  $r$  of 0.78) between the IDAF-4C and the DAS, and the IDAF-4C explained greater variation in dental visiting patterns than the DAS did. Approximately half of those classified as dentally anxious by the

DAS were also categorised as dentally fearful by the IDAF-4C.<sup>19</sup>

Typically, New Zealand Defence Force (NZDF) recruits are adults between 17 and 25 years old.<sup>20</sup> From a dental anxiety and fear viewpoint, this is an important life stage because of the higher risk of onset and/or consolidation of dental anxiety, along with the risk of a marked decrease in dental visits, particularly if individuals do not overcome their dental anxiety.<sup>10,21</sup> They are then likely to carry the burden of their poorer oral health onward through life.

The IDAF-4C was developed to overcome the shortcomings of the DAS but requires more psychometric analysis to determine its utility, especially given the low number of studies that have compared the two measures. Accordingly, this study aimed to compare the psychometric properties of the well-used but flawed DAS and the relatively new and conceptually sound IDAF-4C in a sample of NZDF personnel.

### Materials and methods

Ethical approval was obtained from the University of Otago Ethics Committee (Category B; D18/200) for a cross-sectional study of New Zealand Defence Force (NZDF) recruits and officer cadets. The original sample of participants consisted of 874 recruits and officer cadets (701 males, 80.2%; 173 females, 19.8%) who had entered the NZDF in the 13 months between 1 July 2018 and 31 July 2019. The baseline sample had the following characteristics: one in five were Māori; the age range was 17 to 59 years, with only nine older than 35 years (most were aged between 17 and 24 years); the highest level of education attained by 45% of the sample was primary/secondary school; and one in eight were of high SES.

The current study recontacted 134 individuals at their annual dental check-ups between April and August 2021. After written informed consent was provided, they completed a socio-dental questionnaire prior to their dental examination (note that the questionnaire given to the participants at the time of their initial dental examination did not include any dental anxiety measures. The baseline assessment was largely clinically focused, and we had always intended to bolster the self-report component at the second assessment).

Dental anxiety and fear were measured using both the IDAF-4C and the DAS.<sup>14,17</sup> The IDAF-4C comprised eight items, with two items assessing each of the four different components of anxiety and fear. The response option was a 5-point Likert scale

where respondents placed themselves according to how strongly they agreed or disagreed with an item. A mean score of 3 or more defined someone as dentally anxious.<sup>17</sup> The DAS had four response items for which responses were summed. An individual's score ranged from 4 (least anxious) to 20 (most anxious). A score of 13 and above classified a person as dentally anxious. The global validation item for the two dental anxiety scales was 'Overall, how anxious are you about visiting the dentist?', with respondents asked to place themselves on a 4-point Likert scale, with response options 'Not at all', 'Somewhat anxious', 'Quite anxious' and 'Very anxious'. The global item was placed early within the study questionnaire to separate it from the dental anxiety scale items. It was developed to provide an ordinal global measure of dental anxiety against which the concurrent validity of the two multi-item scales could be assessed; such validity would be confirmed if there was a marked and consistent gradient in mean dental anxiety scale scores across the ordinal categories of the global measure.

Data were analysed using version 26 of the Statistical Package for the Social Sciences (SPSS, Chicago, IL, USA). Confirmatory factor analysis for the DAS and IDAF-4C was undertaken, employing principal axis factoring (with promax rotation) as the extraction method and Kaiser normalisation. The two scales' internal consistency reliability was compared using Cronbach's alpha. Dental anxiety scale scores were then computed, and their concurrent validity was assessed by examining the mean DAS and IDAF-4C scores across the ordinal categories of the global self-reported dental anxiety question. The concordance

between the two dental anxiety scales was examined using Pearson's  $r$  correlation coefficient and a scatterplot.

## Results

Sociodemographic details are not available for the 134 participants in this analysis.

### Confirmatory factor analysis

The exploratory factor analysis for the IDAF-4C showed that single factor loadings were acceptably high and were on a single factor; only one of the Eigenvalues was greater than 1, at 5.8. That single factor explained 72.4% of the variance in the IDAF-4C responses. The Cronbach's alpha was 0.94. The exploratory factor analysis of the DAS showed that the items loaded on a single item and the loadings were acceptably high, with only one of the Eigenvalues greater than 1, at 2.8. This single factor accounted for 69.5% of the variance in the DAS responses. The Cronbach's alpha was 0.85. A summated score of 13 for the DAS and an alternative mean score of 3 for the IDAF-4C were used to define dental anxiety.

### Concurrent validity

The two dental anxiety scales showed reasonably consistent and statistically significant gradients in mean scale scores across the response categories of the global question (Table 1).

### Concordance between the scales

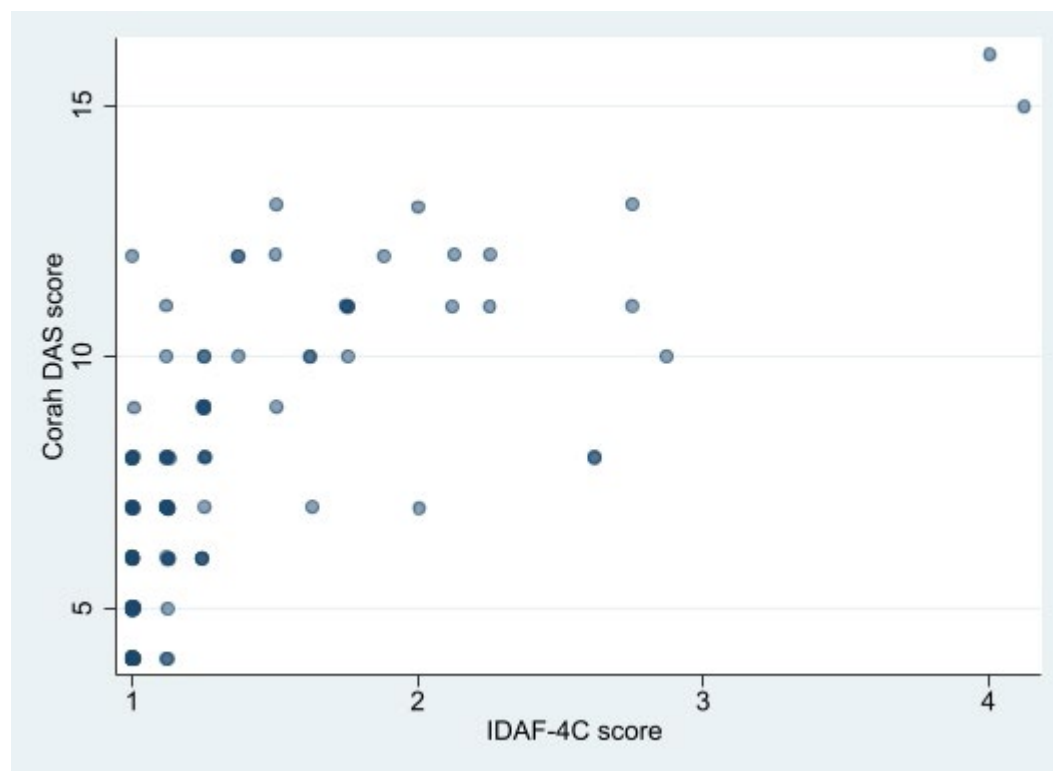
The correlation between the IDAF-4C and the DAS was strong, with  $r = 0.710$ . This is illustrated in the scatterplot (Figure 1).

**Table 1. Concurrent validity of the two scales: mean IDAF-4C score and mean DAS score by responses to the global dental anxiety question.**

Global Dental Anxiety Score	N (%)	Mean IDAF-4C (sd)	Mean DAS (sd)
Not at all	86 (64.2)	1.1 (0.4) <sup>a</sup>	5.8 (1.7) <sup>a</sup>
Somewhat anxious	40 (29.9)	1.5 (0.5)	9.2 (2.3)
Quite anxious	4 (3.0)	2.4 (1.1)	11.8 (3.0)
Very anxious	4 (3.0)	2.9 (0.9)	11.3 (3.0)
All combined	134 (100.0)	1.3 (0.6)	7.2 (2.7)

<sup>a</sup> $P < 0.001$

**Figure 1. Scatterplot of the Index of Dental Anxiety and Fear (IDAF-4C) and the Dental Anxiety Scale (DAS) scale scores (note that the darker data points comprise more observations).**



The prevalence of dental anxiety, according to the IDAF-4C, was 2.2%, while it was 3.7% according to the DAS. The kappa statistic ( $k = 0.486$ ) indicated only moderate concordance between the DAS and IDAF-4C prevalence estimates. Five individuals were classified as dentally anxious by the DAS, but only two were classified as dentally anxious by the IDAF-4C. The IDAF-4C classified three individuals as having dental anxiety, and two of those individuals were classified as dentally anxious by the DAS.

## Discussion

This study compared the performance of two important dental anxiety and fear scales in a sample of NZDF recruits. It found that both had sound psychometric properties and acceptable reliability and validity, and they showed reasonable concordance. Despite this apparent equivalence, the IDAF-4C is likely to be a better measure for use in young adults because of its more robust theoretical underpinning, as highlighted by Armfield<sup>17</sup> (a close read of the original DAS paper<sup>14</sup> shows just how *ad hoc* that measure's development was).

Before discussing the findings in detail, the study's weaknesses and strengths must be considered.

The effective participation rate was relatively low, at 15.3%. Several factors conspired to make it so. The study was originally intended as a complete follow-up of the 874 personnel who had entered the NZDF between 1 July 2018 and 31 July 2019 and whose baseline characteristics have already been reported.<sup>20</sup> However, not all individuals from the original sample could be contacted again because some would have left the Forces. Another external factor was the national lockdown arising from the COVID-19 pandemic; this delayed data collection until April 2021, which meant the period available for that was shorter than initially anticipated. The recruits had also been dispersed across different NZDF bases around New Zealand, meaning time had to be taken to locate them and then send the questionnaires out to the appropriate bases in time for the dental check-ups. All of these factors resulted in a lower participation rate than initially anticipated. While high response rates in surveys are preferred, low response rates do not necessarily lead to bias as long as there are few (or no) systematic differences between the responders and non-responders.<sup>22</sup> We had planned to compare the characteristics of those reassessed and those lost to follow-up. However, an NZDF clerical procedural error meant that respondents' unique identifiers were not entered into



the database before the paper questionnaires were destroyed. Accordingly, we cannot determine the extent to which the relatively low response rate may have affected the findings, and neither are we able to report on the sociodemographic characteristics of our follow-up sample. Notwithstanding these concerns, we did end up with sufficient N to test the number of items being investigated (with a participant-to-item ratio of 11 for the DAS and IDAF-4C combined). A *post hoc* power analysis showed a required N of 16 to show the difference in mean DAS scale score between those responding 'Not at all' and those responding 'Very anxious' to the global dental anxiety question (Table 1) with an alpha value of 0.05 and 95% power to detect a difference (and an effect size of 1.8, calculated by dividing the difference in scores by the SD of the score for those responding 'Very anxious' to the global dental anxiety question).

The NZDF requires individuals to undergo a yearly dental check-up. The IDAF-4C has two items that do not apply to the current study's sample because the personnel have no choice about when or whether they have their yearly dental check-up. Those two items are 'I generally avoid going to the dentist because I find the experience unpleasant or distressing' and 'I delay making appointments to go to the dentist'. Since the participants had entered the NZDF in 2018–19, they would have had at least 3 compulsory dental check-ups. Dental anxiety is associated with symptomatic attendance, leading to more invasive procedures, which themselves serve to exacerbate dental anxiety further.<sup>11</sup> These NZDF recruits and officer cadets may have undergone a degree of operant conditioning through their experience of regular check-ups and non-symptomatic attendance. This may have led to lower levels of dental anxiety and correspondingly lower IDAF-4C scores. This might have affected the concordance between the DAS and IDAF-4C (although that was relatively high) and the validity of the IDAF-4C in this sample.

The primary focus of this project was to assess the validity and reliability of the IDAF-4C scale and to compare it with the DAS. The IDAF-4C is the core module of the IDAF-4C+, a suite of scales used to measure dental anxiety and fear. There is currently no 'gold standard' global dental anxiety scale against which to test the IDAF-4C, so we chose to use the DAS, the most widely used and accepted scale.<sup>14</sup> Validity should also be examined using several approaches.<sup>18</sup> In the IDAF-4C scale's development, Armfield employed several methods to assess its validity, including factor analysis, examining associations with other dental anxiety scales, and determining its ability to predict subsequent dental visiting patterns.<sup>17</sup> We confirmed its factor structure

and internal consistency reliability, examined its concurrent validity against a global dental anxiety question, and then directly compared it with the DAS. There was a high level of internal consistency (Cronbach's alpha = 0.94), and the confirmatory factor analysis showed that a single factor accounted for 72.4% of the variance in IDAF-4C responses. This was higher than in the only other New Zealand study.<sup>19</sup> The IDAF-4C displayed good validity against the global dental anxiety question, with an ascending gradient of mean scale scores across its ordinal categories, consistent with the earlier study.<sup>19</sup> Finally, the IDAF-4C and DAS showed high concordance, as demonstrated in Figure 1. The low overall prevalence of dental anxiety in the sample meant that no firm conclusions could be drawn from this study about the respective utility of the two measures in determining the proportion of the population who suffer from dental anxiety. This was similar to the earlier NZ findings.<sup>19</sup>

This study has contributed to the validation of the IDAF-4C. To continue advancing knowledge in this field, research that investigates the occurrence and associations of dental anxiety with sociodemographic characteristics, oral care and oral status would be beneficial. The ability of the IDAF-4C to predict subsequent dental visits, avoidance of the dentist due to fear and specific stimuli—as well as its test-retest reliability—should be examined in other samples, particularly in populations with more severe dental anxiety and fear. The finding that the IDAF-4C demonstrated excellent psychometric properties, validity and reliability adds to the increasing evidence to support the assertion that the IDAF-4C is a valid and valuable instrument for measuring dental anxiety and fear.

## Acknowledgments

We thank the New Zealand Defence Force for supporting this research, especially the 134 recruits and officer cadets who participated in this study.

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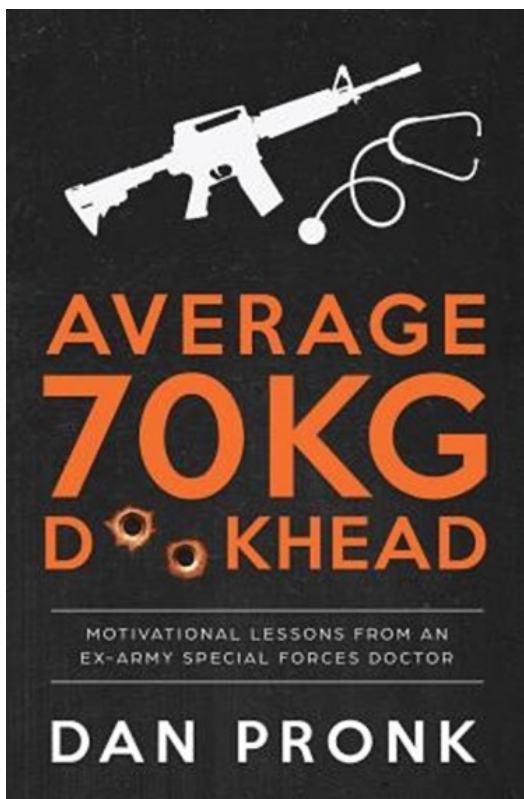
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# Book Review: *Average 70kg D\*\*khead: Motivational Lessons from an Ex-Army Special Forces Doctor*

D Cronshaw



*Average 70kg D\*\*khead: Motivational Lessons from an Ex-Army Special Forces Doctor*

By Dan Pronk. Fremantle: Vivid Publishing, 2019. ISBN 978-1925846744.

Reviewed by Darren Cronshaw

Warning: This review delves into trauma issues that may be distressing to some readers. Support is available through your Chain of Command, Chaplaincy or Health Centre, Lifeline 131144 or Open Arms 1800 011 046.

Dan Pronk tells his story of transformation from a chubby average kid who joins the Army to train as

a doctor and then join Special Air Service Regiment, and lessons he learned during service as a Combat Doctor and afterwards, including navigating post-traumatic stress into a career change.

*Average 70kg D\*\*khead* is my latest number #1 recommendation for recruits from Wagga or Cerberus, especially those experiencing health, discipline or adjustment challenges as they set career and life goals. It is insightful reading for instructors and health professionals supporting Defence members facing resilience challenges. It is also a ripping good read and relevant for anyone eager to dream big, set audacious goals, pursue them relentlessly, and adjust and grow through inevitable setbacks. Pronk's foundational advice: 'We only get one go at this life so don't become comfortable and settle if you're truly convinced that you're destined for something more'.

The first central theme I appreciated was goal-setting inspiration. The book helped me shape goals for my main challenge of supporting wellbeing with attentive chaplaincy support. It elevated service, quoting John Bunyan 'You have not lived today until you have done something for someone who can never repay you'. It urged me to be prepared for tough conversations and challenging relocations. And it reminded me not to compare myself with others but to compete with my yesterday, citing Miyamoto Musashi the 17th-century Japanese swordsman, 'Today is victory over yourself of yesterday'.

Among the book's best advice was to be more concerned with the regard and appreciation of those 'below or around you' than those above, despite what it means for recognition or progression. A meaningful measure of success is the accomplishment of bringing others along! This reminded me of a learner who appreciated a Kapooka Corporal who told them, 'You're not failing if you don't get through but I am failing as an instructor', encouraging them to keep at it together.

The book also helped me break down goals for supporting fitness and language learning efforts. It outlines SMART goals and breaks them into bite-sized plans. If it takes one bite at a time to eat an elephant, then it will take consistency with focused practice to develop my Indonesian language fluency. It takes incremental and consistent effort to increase my number of push-ups and a range of other fitness indicators. Our social media-addicted, fast-paced society expects things to be easy, but if mastery takes Gladwell's predicted 10 000 hours, then I need to respect the need for training hours (as well as coaches and colleagues to support the journey). It takes perseverance and giving 100% in training and events to achieve ambitious goals in endurance sports, which is why Pronk's stories of 'Always a little further', 'Don't leave any gas in the tank' and 'Don't leave any rounds in the magazine' were inspiring. Pronk's stories of selection and Special Forces teamwork will be motivational, especially for those preparing for selection, but it carry lessons for all of us in taking a current project to the next level or overcoming barriers to start something new.

The second theme I appreciated was perspective. This also can help with goal setting—having a bigger perspective to avoid getting stuck in a rut, not taking yourself too seriously, and taking time to celebrate accomplishments. It also helps to have perspective to know when some goals are not worth pursuing or are not achievable. For example, Pronk spent 5 years trying to make it as a professional triathlete until he realised he was underperforming and decided to apply his effort in other directions. He helped remind me that a key to top performance in a central area of effort is saying no to other distracting or alluring options.

The most valuable image of perspective was the recalibrated suck meter. A suck meter is calibrated to what we think is comfortable. Typically, we might sit in an orange zone if food and life and comforts are flowing okay, or tip into a green zone when we see small wins of fortune, or a red zone of 'suck' when we experience simple inconveniences or things not going our way. Australian Defence Force training starts to recalibrate this with expectation management that life and service are not meant to be easy and reinforces that achieving anything worthwhile takes effort. Pronk is transparent about his post-traumatic stress from witnessing violence in combat and the challenges of adjusting to civilian life. But he explains that this also gave him a fresh perspective or post-traumatic growth (PTG). It is possible to experience stress and, instead of slipping into post-traumatic stress disorder (PTSD), to rise up to be stronger and more appreciative. Pronk's

experience may help others navigate trauma and/or gain a fresh perspective:

'Having seen the horrendous rotting meat and produce at the regional markets of a third-world warzone I would find myself in awe of the abundance of fresh choices available at my local supermarket. Having seen kids ripped limb from limb by explosive devices gave me a newfound appreciation for my own kids, and the simple pleasure of being able to safely play at a local park without the fear of every step being their last. Having watched my friends and teammates die on the battlefield I felt a new obligation to really live my life to honour them. I spent more time with my kids because my friends were robbed of the same opportunity with theirs. I invested more in my relationship with my wife for the same reason. The devastation that I saw on the faces of the parents of my dead friends at their funeral services caused me to further invest in my relationship with my own parents. I began to see the minutia of life for exactly what it was.'

Dan Pronk also wrote *The Combat Doctor: A Story of Battlefield Medicine and Resilience*, and, with SF colleagues Ben Pronk and Tim Curtis, wrote *The Resilience Shield: SAS Resilience Techniques to Master Your Mindset and Overcome Adversity*.

Average 70kg D\*\*khead is a valuable resource for ADF members seeking inspiration for achieving bold goals or to help with recalibrating a healthy perspective on life's struggles and the Commanders, health professionals, family and friends who support them.

The views expressed in this review are those of the author and do not necessarily reflect the position of the Australian Army, Department of Defence or the Australian Government.

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# Supporting Health Practitioner Education for the Health and Wellbeing of the Veteran Community

*From the Department of Veterans' Affairs (DVA)*

The Department of Veterans' Affairs (DVA) recognises the vital role health providers provide in supporting lifelong wellness for veterans. However, DVA is also mindful that DVA's health arrangements are unique, complex and can be challenging to navigate. This is especially so for clinicians that do not see many veterans.

The Royal Commission into Defence and Veteran Suicide released its Final Report on 9 September, further highlighting the need for DVA to provide ongoing education to health providers. DVA is taking an integrated approach to improve engagement and awareness of DVA services and arrangements. Over the past eighteen months a number of initiatives have been delivered which include:

- Greater engagement with the Royal Australian College of Practitioners (RACGP) with the implementation of veteran health content on the RACGP Fellowship curriculum and inclusion of veteran topics in the CHECK GP learning program.
- Collaboration with Medcast Pty Ltd, a health professional education provider, to launch a dedicated Veterans Healthcare eLearning Platform "VETs HeLP" on 1st July 2024. The platform provides health professionals with easy access to a range of evidence-based educational resources to support delivery of high quality healthcare to veterans and their families. The platform offers accredited continuing professional development (CPD) opportunities, including interactive webinars, online case scenarios, and other resources. While the training is primarily aimed at GPs, the training resources are applicable to a broader range of healthcare providers.
- Work with the Primary Health Networks (PHNs), to provide two national standard Veteran HealthPathways - Veterans' Health Assessment

and Veteran Referral and Support, providing GPs a real time guide during their consult with their veteran patient. More veterans' pathways are due to be released before the end of 2024.

- Printable quick guides, giving GPs and other specialists the basics on DVA cards, eligibility, billing, compensation, services and programs.
- Establishment of a General Practice Advisory Group (GPAG) with representation from all key primary healthcare colleges and associations. GPAG is pivotal to improving and facilitating engagement and collaboration between DVA and the general practice community.
- DVA also continues to support Psychiatry registrars who wish to train in the Military and Veterans' Psychiatry Training Program by funding training positions in veteran focused mental health services.
- Review and consolidation of DVAs Compensation Forms, supporting a more streamlined approach and providing greater clarity about what is required.

With the mental health of veterans as a priority, DVA has recently established the position of the Chief Psychiatrist, with Dr Jonathan (Jon) Lane acting in this role at this time. Jon is a veteran, academic, and psychiatrist, and works closely with the Chief Health Officer's provider education programs, as well as with Open Arms Veterans & Families Counselling service in both programs and clinical governance. An ongoing multidisciplinary approach to mental health care is complemented by work to embed Open Arms into the Australian health system and include Open Arms in GP referral pathways.

Dr Lane notes having Open Arms clinicians working closely with GPs should improve mental health outcomes and ensure we, as clinicians, are working together for the benefit of veterans and families.



DVA continues to work towards a veteran-ready health sector. Professor Firman, DVAs Chief Health Officer reports “there’s always more work to be done, and more ways we can make it easier for health providers to support DVA clients. We will be guided by the Government’s response to the Royal Commission final report”.

DVA understands the Royal Commission’s report might cause distress among veterans, their families and those who care for them. This includes the many clinicians in our community who are veterans or family of veterans themselves.

Veterans and families can access free counselling and support services through Open Arms Veterans & Families Counselling on 1800 011 046 – 24 hours a day, 7 days a week.

Those who’d prefer to remain anonymous can contact Open Arms Safe Zone Support on 1800 142 072.

Other services for veterans are listed on the mental health support services page of the DVA website. (<https://www.dva.gov.au/get-support/health-support/health-services/mental-health-care/mental-health-support-services>)



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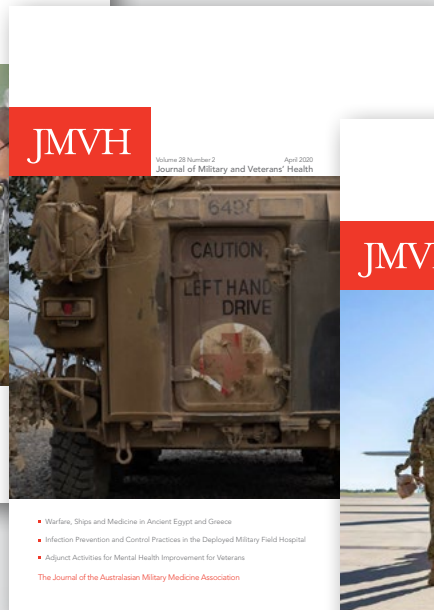
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