

# JMVH

Volume 18 Number 3

July 2010

Journal of Military and Veterans' Health



- Neurology in aviation
- Dengue Fever
- Minimising soldier injuries



The Journal of the Australian Military Medicine Association

Main Entrance

# In the past year...

**1,042,714**

hours worked

**27,013**

timesheets processed

**1,175**

job applications received

**577**

staff working today

**99**

diverse professions

**28**

Defence bases

**1**

team

As the largest supplier of outsourced Civilian Health Practitioner services to the Australian Department of Defence, CM Health provides a wider-range of practitioners than any other recruitment supplier.

**CM HEALTH – Opportunity – Professionals – Advice**



**CMHEALTH**  
OPPORTUNITY | PROFESSIONALS | ADVICE

[defencehealthjobs.com.au](http://defencehealthjobs.com.au) 1300 306 199

---

# Table of Contents

## Editorial

President's Message .....	3
Editorial .....	4

## Original Articles

The true prevalence of unscheduled dental visits in the Australian Defence Force.....	5
Factors affecting oral health status in an elderly military veteran population in New Zealand.....	12

## Review Articles

Neurology in Aviation .....	18
Paediatric aeromedical transport and hypoxia.....	23
Load carriage: minimising soldier injuries through physical conditioning – A narrative review.....	31

## Reprinted Articles

The development of dengue vaccines and their military significance .....	39
Dengue fever update.....	42

## Book Reviews

Are we ready? Public health since 9/11 .....	44
Therapeutic Guidelines: Cardiovascular* .....	46

Instructions to Authors .....	48
-------------------------------	----

Copyright Policy .....	56
------------------------	----

---

# Journal of Military and Veterans' Health

## EDITORIAL BOARD

Dr Andrew Robertson (Editor in Chief)  
Associate Professor Scott Kitchener (Managing Editor)  
Dr Graeme Cannell  
Dr Keith Horsley  
Dr Peter Leggat  
Professor Malcolm Sim  
Dr Bob Stacy  
Dr Darryl Tong

## INTERNATIONAL ADVISORY COMMITTEE

Mohd Zin bin Bidin, Malaysian Armed Health Forces  
Ken Boffard, University of Witwatersrand  
Anne Campbell, former DG NZ Defence Medical Services  
Annette Dobson, University of Queensland  
Mike Dowsett, former DG Naval Health Services Australia  
Greg Gray, University of Iowa College of Public Health  
Jane Risdall, UK Defence Medical Services  
Art Smith, Uniformed Services University of Health Sciences  
Tyler Smith, US Millennium Cohort Study  
Kate Venables, Oxford University  
Simon Wessely, King's Centre for Military Health Research

# Australian Military Medicine Association

## PATRON

MAJOR GENERAL Paul Alexander  
Commander Joint Health and Surgeon General  
Australian Defence Force

## COUNCIL

President	Dr Greg Mahoney
Vice President	Dr Nader Abou-Seif
Secretary	Dr Janet Scott
Treasurer	Dr Neil Westphalen
Council Members	Mr Kerry Clifford Dr Stephanie Hodson Dr Andrew Robertson Mr Geoff Robinson
Public Officer	Ms Paula Leishman

## STATEMENT OF OBJECTIVES

The Australian Military Association is an independent, professional scientific organisation of health professions 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.

---

ISSN No. 1835-1271

## President's message

Greetings and welcome to the new age of professional oversight with the new national professional boards commencing on the 1st July. Let us hope that our personnel contact with these new boards is minimal.

As it is a new financial year, I would remind members that their membership renewal is due and that the AMMA conference and JHC Symposium is rapidly approaching. Please register as soon as possible to avoid the last minute hassles of registering and finding accommodation in Canberra. The organising committee, ably lead by the indomitable Dr Nader Abou-Seif, is well advanced in ensuring this conference will be one not to miss.

David Mearns has confirmed that he will be speaking on the search for the Hospital Ship CENTAUR which he directed late last year on behalf of the Queensland Government. He has a wonderful series of underwater images of the shipwreck, showing the Red Cross on the side of the ship and hospital beds on the seafloor, that would feature in his presentation and he would also use part of his talk to highlight the role of hospital ships during the war and the part played by key medical personnel.

Congratulations must go to Air Commodore Hugh Bartholomeusz OAM and, Colonel Craig Schramm CSC, AMMA members honoured in the Queen's Birthday Honours List. I am sure all members of the Australian Military Medicine Association would like to offer them hearty congratulations on achieving these rare and richly deserved distinctions. It is pleasing to see that the efforts of outstanding health personnel are being recognised.

Finally, I would like to add that AMMA council is exploring ways in which we can improve the distribution, funding and look of the journal. We know that AMMA members are involved in areas of research and have experiences that are both of interest, and potentially of help to our membership and I take this opportunity once again to encourage you all to consider submitting an article to JMVH. As an association we can only benefit from your experiences and knowledge and your contribution will also help in the growth of the journal and the improvement of the association.

I look forward to seeing members and friends of AMMA at our spectacular conference of the 29th October.

Greg Mahoney  
President



## AMMA MEMBERSHIP

Become an AMMA Member and receive a welcome gift and certificate plus receive the *Journal of Military and Veterans' Health* quarterly.

To become an AMMA Member or to renew your membership for 2010/2011 go to the AMMA website where payment can be made at our secure online payment facility and contact details can be updated.

Or contact the AMMA Secretariat on P: 03 6234 7844  
E: [secretariat@amma.asn.au](mailto:secretariat@amma.asn.au)

[www.amma.asn.au](http://www.amma.asn.au)

# Lessons Learned

One of the important lessons that all military health personnel should learn early on is that, as originally expostulated by George Santayana, “those who cannot remember the past are condemned to repeat it.” I have recently reviewed some old letters from my Great-Uncle Captain Gordon Ochiltree Robertson, who served as the Regimental Medical Officer (RMO) for the 57th Battalion A.I.F from 13 March 1918 until the 24 April 1919. His RMO’s report for the month of October 1918 was enlightening, as follows:

“On the night of 1st/2nd we were relieved from the line running just west of ESTREES and proceeded back to the canal bank north of BELLICOURT. On the 2nd October we marched back to TEMPLEUX. We then moved back to PERONNE and on 8th/9th we entrained to MARTAINNEVILLE and marched to our present position in three villages. Some of the billets were found to be good but some are only dirt floors and very poor walls and roofs.

There was an absolute absence of sanitary arrangements when we first arrived and ablution troughs and latrines had to be provided from biscuit boxes and tins salvaged and collected from canteens. After about 2 weeks ablution troughs came to hand through Brigade to whom application had been made from the start. The sanitary section were unable to provide much material owing to the general shortage.

Illness since in this area has been practically normal except for influenza, of which a fair number of cases have been evacuated.

Owing to lack of suitable accommodation a sick hut is not established but minor cases of boils, impetigo and similar cases are being treated in the lines. A few cases of venereal disease have been evacuated during the month but in every case the men were infected while on Paris or English leave. The men now are in better condition than when they left the line but are by no means completely restored to their normal mental and physical condition.

Stretcher bearers are being trained as much as possible under the circumstances but owing to our being billeted in 3 different villages I have been unable to lecture to the bearers as frequently as I wish to and have had to entrust the bulk of the training to my N.C.O.’s.

I have attended to about 20 cases of illness among the Civilians (French). One case of broncho pneumonia which died in Hospital in ABBEVILLE, one maternity case and the remainder influenza of greater or less severity.”

Even in this short report from near the end of the war, we see the important issues of sanitation, bacterial skin infections, sexually transmitted diseases, logistics, first-aid training, mental health, pandemic influenza (although they probably did not know it at this stage) and even obstetrics addressed. All of these issues remain important considerations in the health management of fighting troops and, although we have far better pharmaceutical options than in Captain Robertson’s time, I wonder if we really have sorted out the broader environmental health, logistic, mental health and training issues in 2010.

Sixty years ago, on 25 June 1950, North Korea invaded South Korea. Australian forces were committed immediately and were to be involved in the fighting over the next three years. In remembrance, the Journal is intending to publish a Korean War themed issue in April 2011. I would encourage all our readers who have had an involvement with the Korean War, through veterans, family or a general interest in the conflict, to consider submitting an article on this theme. As always, other articles on the military and veteran’s health theme are most welcome, as represented by the excellent calibre and range of articles in this issue.

Captain Andy Robertson, CSC, RANR  
Editor-in-Chief

# The true prevalence of unscheduled dental visits in the Australian Defence Force

Dr Greg Mahoney<sup>1</sup>, Prof Gary Slade<sup>2</sup> and Assoc Prof Scott Kitchener<sup>1</sup>

## Abstract

**Background:** An essential element for determining suitable risk management strategies for dental emergencies in the Australian Defence Force (ADF) is an accurate measurement of that outcome which best reflects those dental visits collectively termed 'unplanned presentations'.

**Purpose:** The aim of the study was to determine the true prevalence of Unscheduled Dental Visits (UDVs) in the ADF.

**Method:** A cross-sectional study was conducted on 878 deployable ADF personnel. Measurement of UDVs was determined by a dental chart audit of participants and a questionnaire to participants on any presentations to non-ADF dental centres and other health professionals for reasons relating to their oral health. Additionally, the reason for these presentations to both the ADF dental centres and non-ADF dental centres were recorded so as to exclude those visits of a trivial or non-dental nature.

**Results:** The study found that the documented prevalence of UDVs was in line with previous studies (16.2%) but when visits to non-ADF dental centres were considered, there was a significant underreporting of UDVs (20.2%). A comparison with the Australian population showed a similar prevalence of UDVs for those who received an annual dental examination (ADE) and who had private health insurance. But for Australians who forego ADEs and have no private health insurance, the prevalence of UDVs increases by a factor of 2.5. A breakdown of the reasons for UDVs showed no significant difference between total UDVs and the documented UDVs, with fractured and broken teeth and fillings (33.9%) being the most common reason for a UDV.

**Conclusion:** The results indicate that UDVs are underreported in the ADF. The significance of the underreporting is that it results in incomplete dental records for forensic and treatment planning purposes, loss of quality control; and an inability to accurately predict UDVs on deployments and provide proportionate dental support. Finally, it should be noted that low UDV prevalence is conditional on continual ADEs and universal access to dental care.

## Background

The goal of the Defence Health Services (DHS) is to make and maintain ADF members 'fit to fight'. Health strategies based on this goal have to be focused not only on the notion of 'fit to fight' but 'fit for living and life'. Strategies which ignore the latter would be short-sighted. In dentistry, there is a need to have a suitable risk management strategy to initially screen ADF members in order to identify at-risk patients and plan intervention strategies so as to achieve these goals. This risk assessment must be sensitive enough to accurately estimate the likelihood that a dental problem will occur. Focused treatment planning at this stage will give better long-term dental outcomes in the ADF with fitter members and more stable dentitions<sup>1</sup>. The (American) National Institute of Health suggests that all patients should not be treated in the same fashion, but rather prevention programs should be matched to the disease risk of the individual

patient<sup>2</sup>. Additionally, a suitable pre-deployment risk management assessment is essential so that dental casualties are better managed, either by preventing most casualties or better management of casualties in the field<sup>3</sup>.

In determining a suitable risk management assessment of deployed personnel, it is necessary to define what outcome(s) needs to be measured so as to capture dental casualty numbers accurately. In the past researchers have focused on the concept of the dental emergency, but what is meant by dental emergency has been somewhat vague. In July 2006, an international workshop at the Great Lakes Naval Base, Illinois was held to standardize military dental research definitions, in order to achieve agreement on what should be measured. The consensus from the workshop was that dental emergencies are *presentations at the dental surgery where the patient is in pain or sufficient discomfort that they are unable to discharge their duties*

to the standard required. While unscheduled dental visits (UDVs) are defined as *any visit to the dentist which is not part of their dental treatment plan following their Annual Dental Examination but doesn't include matters of a trivial nature such as orthodontic consultations and impressions for mouthguards*<sup>4</sup>. It is this outcome that researchers need to capture because UDVs reflect the range and frequency of visits to the dental units both while on deployment and in garrison.

### Methods

A cross sectional study was conducted amongst 878 deployable personnel in the Australian Defence Force (ADF) stationed at seven ADF bases. The bases were selected because they had the largest numbers and highest proportion of deployable personnel from among the 79 bases that house Australia's deployable personnel. They were located in four Australian jurisdictions: New South Wales, Victoria, Queensland and the Northern Territory. Study subjects were selected at the time of their mandatory annual dental examination (ADE), with the intention to enroll approximately 10% of personnel at each base. This was to be achieved by selecting all subjects who completed their ADE within a period of five consecutive weeks during 2006. Where enrolment was slower than expected, the period was extended in an attempt to enroll the target of 10% of the base's population. Ultimately, enrolment occurred over periods of up to three months.

For the purpose of the study, unscheduled dental visits were defined as *any visit to the dentist in the previous twelve months which was not part of their dental treatment plan following their ADE, but excluding matters of a trivial nature such as orthodontic consultations and impressions for mouthguards*<sup>4</sup>. In light of this the calculation of the prevalence of total UDVs was determined as:

1. The number of UDVs as reported in a dental records audit,
2. The number of self-reported visits to non ADF employed dentists, and
3. The number of self-reported visits to other health professionals for problems relating to the mouth or jaw.

Excluded from this count were:

1. Visits for trivial or non-dental reasons such as:
  - a. Impressions for mouthguards,
  - b. Orthodontic consultations, and
  - c. Tonsillitis.
2. Participants who self-reported UDVs but responded negatively to the questions,

*Did you have a problem? or Was the visit necessary for the relief of pain?*, and whose explanations for their visits were inadequate, and

3. Double and Triple positive responses to having a UDV.

All three Services were included, as there may have been differences in presentations for UDVs between the services. The study had an unequal number of males (779) to females (99), reflecting the gender balance in the ADF. The age range was between 17-56, with the majority of participants falling within the 17-35 year range, again reflecting the range in the ADF5.

A comparative Australian population was identified using the data from the National Survey of Adult Oral Health (NSAOH) 2004 -20066. In using the NSAOH, a positive UDV was assessed as a person:

1. Between the ages of 17-55,
2. Having private health insurance,
3. Usually visit the dentist for an annual checkup, and
4. Who had visited the dentist for a problem within the last 12 months.

As data on participants' presentation to other health professionals for oral problems was not available in the NSAOH data, comparisons with the ADF data was limited to the documented UDVs and those visits to non-ADF dental facilities.

### Results

#### Target population

Table 1 shows the distribution and returns from each of the 7 selected sites with 69.9% of respondents coming from the Army, 25.5% from the Air Force and 4.6% from the Navy.

ADF Centres	Responses (distributed)	Percent	Cum.
Enoggera (Army)	150 (222)	17.1	17.1
Darling Downs (Army)	100 (100)	11.4	28.5
HMAS Manoora (Navy)	40 (100)	4.6	33.2
Darwin (Army)	188 (189)	21.6	54.8
Townsville (Army)	150 (150)	17.1	71.9
Albury (Army)	24 (40)	2.7	74.5
Amberley (AirForce)	224 (224)	25.5	100.0
<b>Total</b>	<b>876*</b>	<b>100.0</b>	

\* 2 Observations were dropped due to incomplete returns

Table 1. Distribution of the questionnaire responses

UDVs

Whether the participant had a UDV in the past 12 months is illustrated in Table 2. 16.2% of the participants had a documented UDV in the preceding 12 months, while 6.6% presented as UDVs to non-ADF dental centres and other health professional.

UDV Measures	Yes	No	Total	Prevalence %
Documented UDVs	142	734	876	16.2
UDVs at Non ADF centres	38	827	865	4.4
UDVs at Other Health Professional	19	847	866	2.2
<b>All UDVs</b>	<b>178*</b>	<b>698</b>	<b>876</b>	<b>20.3</b>

\* Double and triple counts are counted as one

Table 2. Summary of UDVs in study population

The combined total of all UDVs within the last twelve months, after eliminating double and triple counts, was 20.3% (178 of 876) of the participants.

Variable Age	UDV%	
	No	Yes
17-24	77.2	22.8
25-34	85.3	14.7
35-44	76.6	23.4
44-56	66.7	33.3
	Pearson chi2(3) = 12.6 Pr = 0.005	
Rank Officer	88.7	11.3
SNCO	75.9	24.1
JNCO	80.6	19.4
Other	77.6	22.4
	Pearson chi2(3) = 9.2 Pr = 0.03	

Table 3. Percentage of UDVs by age and rank

	ADF pop	Age Adjusted Aust pop	Adjusted Aust pop With ADE and Insurance	Adjusted Aust pop without ADE and with Insurance	Adjusted Aust pop without Insurance with ADE
Prevalence of UDV(%)	20.0	32.8	19.9	42.4	49.4
95% CI	17.3, 22.6	31.3, 34.4	17.7, 22.2	39.0, 45.8	46.4, 56.6

Table 4. Comparative effects of ADEs and health insurance on the UDV prevalence

Comparative Age Groups	UDV	
	Percentage With UDV	95% Conf. Interval
<b>Age 17-24</b>		
Age adjusted Aust pop	23.3	20.0, 26.9
Adjusted Aust pop	12.3	8.4, 17.5
ADF pop	23.5	18.6, 28.3
<b>Age 25-34</b>		
Age adjusted Aust pop	32.4	29.0, 35.9
Adjusted Aust pop	19.1	14.5, 24.7
ADF pop	14.1	10.4, 17.9
<b>Age 35-44</b>		
Age adjusted Aust pop	34.7	32.1, 37.4
Adjusted Aust pop	20.1	16.7, 24.1
ADF pop	22.0	16.3, 27.6
<b>Age 45-54</b>		
Age adjusted Aust pop	38.4	35.8, 41.1
Adjusted Aust pop	25.2	21.6, 29.2
ADF pop	32.3	15.7, 48.9
<b>Total</b>		
Age adjusted Aust pop	32.8	31.3, 34.4
Adjusted Aust pop§	19.9	17.7, 22.2
ADF pop*	20.0	17.3, 22.6

\* All ADF data is adjusted to exclude other professional visits for oral problems.

§ Adjusted for Age, annual dental check-up and private health insurance

Table 5. Comparison of the UDV prevalence and the Australian population by age

UDVs by age, rank

It is known that age and military rank are significant confounders for lifetime caries experience in the ADF population<sup>7</sup>. Table 3 illustrates the variations in UDVs and these potential confounders and UDVs.

Reason	Percent of Documented UDV	Percent of total UDV
Fractured Teeth/filling	33.9	33.8
Caries	10.6	11.5
Pros, endo or periodontics	15.5	15.4
TMD	5.6	3.8
Post-op or Surgical	11.1	11.5
Wisdom teeth	10	6.2
Sensitivity	7.2	10
Other	6.1	7.8
<b>Total</b>	<b>100</b>	<b>100</b>

Table 6. Breakdown of the reasons of UDVs

The results indicate that the variables of age and rank are significant and that while change in age is not monotonic there is a trend of increasing UDV prevalence with age, whereas rank shows a lower prevalence for officers.

#### Comparison with the Australian population

Data on the Australian population was drawn from the National Survey of Adult Oral Health<sup>6</sup> where a UDV was defined as visiting the dentist within the last twelve months for a problem. A comparative population was gained by adjusting for age, for annual visits for a checkup, and whether the person had private health insurance. The comparison with the Australian population (Table 4) shows a significant difference between the ADF population and the general public (32.8% to 20.0%). However, after adjusting for visiting patterns and health insurance coverage, the ADF's UDV prevalence is comparable to the 19.9% found after these adjustments. Table 4 also shows the effects on the UDV prevalence when a population does not have access to ADEs and/or Health Insurance, with an increase of UDV prevalence to 42.4% and 49.4% respectively.

Table 5 is a comparison of the UDV prevalence across the different age categories. This shows that there is an increase in the UDV prevalence with increasing age, although the ADF population is significantly over-represented in the 17-24 year old category because this age group represents the majority of the ADF.

#### Reasons for unscheduled dental visits

Breaking down the causes of UDVs is essential to an understanding of how UDVs may be prevented. Accordingly, causes were allocated to one of 8 categories to reflect the range of responses, while avoiding categories which had too few or too many responses to be meaningful. In Table 6, it can be seen

Study	Year	Place	Type	AIR*
Ludwick and Gendron	1969	Vietnam	Conflict	210
	1970	Vietnam	Conflict	157.2
Payne and Possey	1981	USA	Garrison	167.4
Tweles and King	1982	Sinai and Egypt	Peace keeping	160
Swan and Karpetz	1985-1992	Canada	Deployment	116-153
Deutsch et al	1991	Kuwait/Iraq	Conflict	149.3
Mahoney	2000	East Timor	Peace keeping	269
Richardson	2003	Kuwait/Iraq	Conflict	160
Dental Risk Study	2006	Australia	Garrison	20.3†
Dental Risk Study (Recorded UDVs)	2006	Australia	Garrison	16.2 ‡

\* Annualised Incidence Rate. Incidence per 1000 over one year

† Period Prevalence

‡ Period Prevalence

Table 7. Comparative dental emergency/UDV rates

that there is little change in the breakdown of the reasons for UDVs between the ADF and the general Australian population.

## Discussion

### Target population and response rate

In the initial protocols, it was intended that the questionnaires would be distributed among the three Services in the ADF in proportions that reflected each Service's operational personnel contribution. Attempts were made to elicit increased responses from the Navy; however, due to the operational requirements of both fleet bases and the shortage of suitable personnel to oversee the conduct of the study at these sites, these important subpopulations could not be included in the study. It was believed that the Navy might have had issues with access to dental care during maritime operations, where dental access might be assumed to be limited. As can be seen by the breakdown of this distribution in Table 1, the Navy responses were entirely from one source - HMAS MANOORA during Exercise RIMPAC over a small period of time. The dental officer

in MANOORA reported that the response rate was less than he had hoped for. The high workload before and during the Exercise meant that many on board declined to participate.

This was certainly not the experience with the Army and Air Force, with very few declining to participate. In general, the returns from the questionnaires were excellent, with 85.6% distributed questionnaires returned. A few of these returns were discarded due to their incompleteness. It is believed that the generally high participation rate was due in part to the presence of dental officers at the bases to oversee the conduct of the study.

### UDV prevalence

As described in the results Table 2, the true prevalence of UDVs was 20.3%. The difference in the prevalence of 4.1% between recorded UDVs and the real rate of UDVs means that 20.2% of UDVs are not reflected in the dental documentation.

A comparison of the study's findings with other studies is shown in Table 7. Whilst other studies measure an incident rate<sup>3</sup> of dental emergencies, as opposed to the prevalence of UDVs, some comparisons can still be made.

From Table 7 it can be seen that the recorded prevalence (in the dental documents) is within the range of expectations. It should also be remembered that many of the above studies were recording dental emergencies (often this was ill-defined) and therefore were unlikely to record mild cases of Temporomandibular Joint Dysfunction (TMJD) or sensitivity.

### Age and rank

The increase in UDV prevalence across the age categories was not monotonic in the ADF population, and the prevalence in the 17-24 year old age group was significantly higher than for the adjusted population at 23.5% to 12.3%. It is hypothesized that this may be due to a number of factors: the young ADF population may have poorer oral health than a comparable Australian population, as evidenced by their higher Decayed Missing and Filled Teeth score (4.0 cf 3.2) and the young ADF population may have risk behaviours for UDVs that are higher than the general Australian population.

The differences between ranks is also interesting, with officers having a markedly lower UDV prevalence of 11.3%. While it is expected that Senior Non-Commissioned Officers (SNCO) would have a higher prevalence given that this represents an older age group, officers still have a lower UDV prevalence after adjusting for age against all ranks.

### Comparison with the Australian population

The comparative analysis of the UDV prevalence and the adjusted Australian population (as seen in Table 5) indicates that the prevalence in the ADF population is remarkably similar to the Australian population of the same age range and dental visiting habits (19.9% to 20.0%). Table 5 also shows that, for the same age range, if ADEs are not performed, even though they have private health insurance, the UDV rate increases significantly to 42.4%. Further to this, a lack of private health insurance increases the prevalence to 49.4%

The results strongly suggest that the critical factor in reducing the prevalence of UDVs is the ADE and that a lack of affordable access to dental care further exacerbates the problem. This is in line with expectations, given that ADEs should identify potential problems before the patient becomes aware of them, but once an individual realizes they have a dental problem, then the issue of affordability would be of lesser concern. Additionally, if the ADF were to remove the universal requirement for an ADE then the UDV prevalence would increase significantly. That is not to say that some individuals could not safely afford to have a dental examination less frequently, given their individual low risk for becoming a UDV.

### Reason for UDVs

Essential to an understanding of how UDVs may be prevented is breakdown of the causes of these UDVs. Table 7 compares these findings with previous studies of Australian, US, and British Defence personnel<sup>8-10</sup>.

The breakdown consistently indicates that fractured/broken fillings and caries are the most frequent reasons for UDVs. On this basis, treatment and prevention strategies should be implemented to reduce the occurrence of these dental events. Interestingly, though this was first reported 37 years ago, it remains the major reason for UDVs today, and furthermore, the prevalence of UDVs remains the same as it was 37 years ago.

Clearly, from the study, there appears to be an under-reporting of unscheduled dental visits in the ADF. The implications of this under-reporting are:

- An incomplete individual dental record for forensic and treatment history purposes. The wide range of reasons and the significant number of these presentations means that there may be substantial discrepancies in an individual's dental records. Examining dentists would have difficulty in assessing an individual's treatment history to assist in their treatment planning if the records were incomplete. There would be problems, too, in victim identification as often Defence personnel deaths are the result of some catastrophic event and identification may be obliged to rely on incomplete

records of an individual's oral health status.

- ADF members visiting non-ADF dental centres are receiving treatment which may or may not be desirable from the ADF's point of view. For example, members seeking treatment for fractured and broken fillings and teeth will often receive posterior composite resin fillings, which may be more susceptible to further fracture. This leads to the dilemma on return to the ADF dental centre of whether to accept the inferior filling or replace it. This situation will lead to a lack of quality control and consistency in terms of the standard of treatment provided to ADF members.
- An underestimation of what would be required to deal with these UDVs for military health planning purposes. Personnel and material for health deployments are based on known casualty rates. If the reported rates are too low, then this may lead to a reduced dental fitness of the deployed force and hence a reduced number of fit personnel for the mission.

Furthermore, the prevalence of UDVs has operational significance as 16-20% of deployable personnel, who are deemed dentally fit, are likely to experience a dental problem within the following 12 months, which clearly cannot be predicted under the present dental classification system. This prevalence suggests that there is a continuing need to maintain the capability to deploy dental teams in the field, based on the numbers of personnel deployed and the prevalence of UDVs.

### Conclusion

This study indicates that there is a significant under-reporting of UDVs in the ADF. Over 4% of ADF personnel visit non-ADF dental centres and other health professionals on occasion for problems associated with their oral health. This represents 20% of all UDVs. The implications of this under-reporting and external treatment are:

- Incomplete individual dental records for forensic and treatment history purposes,
- Loss of quality control over dental treatment, and
- Underestimation of what would be required to deal with these UDVs for military health planning purposes.

The overall high prevalence of UDVs within the deployable ADF population also indicates that there is a continuing need for the operationally deployable dental officer.

The comparison of UDV prevalence in the ADF and the Australian population indicates that the rate is equal to a similar age group who has annual dental examinations and has health insurance. Furthermore, the removal of the requirement for ADEs and the provision of dental treatment without a validated predictive evaluation of a member's risk of UDV would be expected to significantly increase the UDV prevalence.

*Authors affiliations: <sup>1</sup>Centre for Military and Veterans Health, Qld and <sup>2</sup>UNC School of Dentistry, North Carolina, USA. Corresponding author: Dr Greg Mahoney BDSc, Grad Dip Clin Dent, MSc(Dent), Centre of Military and Veterans' Health, University of Qld, Herston Road, Herston, Qld. 4006. Email: g.mahoney@uq.edu.au*

Reason	Dental Risk Study (2006)	Gulf (2003) British Army	Timor (2001) Australia	Gulf (1991) US Marines	Vietnam (1970) US Marines
Fractured Teeth/filling Caries	44.5	61.8	64.5	38.9	52.9
Pros, endo or perio	15.5	11.9	10.5	26.1	16.5
TMD	5.6				
Postop or Surgical	11.1	3.8	21.0	6.0	12.1
Wisdom teeth	10	13.1	4.0 §	17.8	18.5
Sensitivity	7.2				
Other	6.1	9.4		11.2	
Total	100	100	100	100	100

§ Deployed ADF in general will have had partially erupted 3rd molars removed.

Table 8. Comparative studies of dental emergency reasons

### References

1. Newman M. Assessing Risk Improves Predictability of Treatment Outcomes. *Quintess Inter* 1999;29(12): 806-11.
2. Diagnosis and management of dental caries throughout life. NIH Consensus Statement 2001;18(1):1-23.
3. Mahoney G, Coombs M. A Literature Review of Dental Casualty Rates. *Mil Med* 2000;165(10):751-6.
4. Simecek JW. What should we be measuring? In: Simecek JW, editor. Defence Dental Workshop on Dental Emergencies; 2006 Jul 2006; Great Lakes Naval Base 2006.
5. Defence Do. Defence Census 2003: Australian Government; 2003.
6. Slade G, Spencer A, Roberts-Thompson K, (Editors). Australia's dental generations: The National Survey of Adult Oral Health 2004-06. Canberra: Australian Institute of Health Welfare (Dental Statistics and Research Series No34); 2007.
7. Hopcraft MS, Morgan MV. Exposure to fluoridated drinking water and dental caries experience in Australian army recruits, 1996. *Community Dent Oral Epidemiol* 2003;31(1):68-74.
8. Richardson PS. Dental Morbidity in the United Kingdom Armed Forces, Iraq 2003. *Military Medicine* 2005;170(6):536-41.
9. Mahoney G. The Role of the Dental Officer in the Australian Defence Force [Master of Science]. Sydney: University of Sydney; 2001.
10. Deutsch W, Simecek J. Dental Emergencies Among US marines in Operation Desert Storm/ Shield. *Mil Med* 1996;161(10):621.

# Factors affecting oral health status in an elderly military veteran population in New Zealand

Mr Darryl Tong MBChB, MSD, FFDRCSI, FDSRCS, FACOMS, Dr James Dawson BDS,  
Professor Robert Love MDS, PhD, FRACDS

## Abstract

**Background:** Oral health care provision for aged-care facility residents remains problematic worldwide, with both institutional and professional barriers preventing regular provision of this service.

**Purpose:** To identify factors affecting the oral health status of elderly war veterans which are different from those reported for non-veteran aged-care facility residents.

**Methods and Materials:** A small pilot study of 30 aged-care facility residents was performed at a dedicated rest home and hospital for war veterans in Dunedin, New Zealand. The study included data collection and a clinically-based head, neck and oral examination for each of the participating residents to establish a base-line. Oral health data were then integrated with the general medical notes and recommendations for each resident were given in terms of oral health maintenance with appropriate referrals for treatment needs. A literature review was performed using web-based on-line search engines to compare the oral health needs of these veterans with other non-veteran aged-care facility residents.

**Results:** The oral health status and needs of elderly war veterans are no different to other aged-care facility residents in terms of oral hygiene needs, edentulism, dental caries and periodontal disease. Common medical conditions and medications affect both veteran and non-veteran aged-care facility residents in a similar manner. However, poor oral health status was strongly associated with significant mental illness which may be more prevalent in a veteran population and include depression, anxiety disorder, post-traumatic stress disorder (PTSD) and alcohol abuse.

**Conclusion:** The oral health care needs of a veteran population do not differ greatly from the needs of other non-veteran aged-care facility residents but greater consideration should be given during assessment for possible service-related oral conditions and mental illness issues including PTSD and alcohol abuse.

## Conflict of interest

The authors declare no conflict of interest and have not received any material or monetary gain in the preparation of this article.

## Introduction

The provision of oral health care in aged-care facilities remains problematic world-wide. Inadequate staff training, limited resources (both financial and staffing levels), patient compliance issues and a fundamental lack of appreciation for oral health appear to be common barriers in providing even the most basic oral health care to these individuals<sup>1-4</sup>. The poor provision of routine oral health care in this population is not limited by institutional barriers alone; the dental profession itself also contributes to this ongoing problem. Antoun et al. reported that general dental

practitioners are reluctant to engage in older people's oral health, citing the inconvenience of leaving their practices to visit long term care facilities and poor financial remuneration as the main reasons<sup>5</sup>.

Numerous studies have identified that residents in aged-care facilities require regular dental maintenance due to decreasing rates of total edentulism with more residents requiring prosthetic rehabilitation, periodontal treatment and caries control for their remaining dentition<sup>3,5-9</sup>. In addition to this background picture, subsets of these residents may require even greater dental input such as individuals who are totally dependent on others for routine care (hospital level care residents) and elderly patients with significant psychiatric disorders<sup>6,10</sup>. Another subset also warrants greater consideration – that of elderly military veterans who not only deal with the same

issues as other aged-care residents but also may have other issues affecting oral health that may be related to military service. Montecillo War Veterans Rest Home and Hospital (Montecillo) in Dunedin is one of four facilities in New Zealand dedicated to the care of war veterans or their dependents. Like all aged-care facilities, criteria must be met before an individual is accepted into Montecillo; however the nature of a facility for war veterans imbues a special character and ethos that is unique. The goals of this pilot study were to identify factors affecting the oral health care status among a small population of war veterans in New Zealand; to compare their oral health needs against those reported for the greater population of non-veteran residents in other aged care facilities by way of literature review; to provide clinical oral and head and neck examinations for participating residents and to integrate an oral health care plan into the existing general medical records (under a separate section with regular reviews). This information may be used as a basis for future longitudinal studies of veterans' oral health needs both regionally and nationally and the development of a potential template for an integrated oral health care plan for aged care facility residents.

### Methods

Residents of Montecillo were asked for their voluntary participation in this study. An information sheet and a written consent form were provided to the residents and their families. The families were asked or power of attorney sought for those residents unable to consent for themselves in order to provide written consent on their behalf should they wish to participate in the study. Ethical approval was obtained prior to this study from the University of Otago Ethics Committee and general consent from the Board of Trustees of Montecillo.

Once identified and consented, each participating resident received an interview to reiterate the purpose of the study, their pertinent medical and dental history was reviewed and a clinical head, neck and oral examination was performed. The service history of the resident was also recorded with details of overseas operational deployment noted in particular. No periodontal or dental probing was performed and no radiographs were taken. The intraoral examination was performed using a dental mirror with a head mounted LED light used for illumination. A standard charting system from the School of Dentistry, University of Otago was used to record the remaining dentition, restorations and clinically visible pathology. The data was recorded and the medical history (including medication list) and service history cross-referenced with the resident's existing medical records. Any pathology or dental needs were

identified and recommendations noted in the records, which included the appropriate referrals for follow up care. No invasive procedures or provision of treatment was performed as part of this initial study. For the purposes of a comparative literature review, web-based on-line search engines (PubMed, Medline, Ovid, and e-medicine) were used to identify the relevant publications with key words including oral health, aged care facilities, gerontology and veterans.

### Results

The reporting period for this study was 6 months (March to August 2009) and conducted exclusively at Montecillo War Veterans Rest Home and Hospital. Of the forty-four residents living at Montecillo at the time, thirty residents consented for participation in this study (68%). In this study group, twenty seven were male (90%) and three were female (10%). The average age was 85 years and ranged from 65 to 95 years. Two thirds of the study group were assessed as needing rest home level care and the remainder hospital level care with more intensive nursing supervision.

Over three quarters of the study group had either regular force or reserve force service backgrounds (77%) with the majority of these individuals having served in the army (60%). Half of the veterans had overseas operational deployment experience with almost 90% of those having served in the Second World War and the remainder having served in Malaya or Indonesia (including one former Royal Netherlands Army soldier). Of the Second World War veterans, eleven individuals served in the Middle East and/or European Theatres of Operation and three served in the Pacific. Table 1 summarises this data.

Males	27 (90%)
Females	3 (10%)
Total sample	30 (100%)
Average age of participant (age range 65-95 years)	85 years
Previous military service background	23 (77%)
Army	18 (60%)
Air Force	4 (13%)
Navy	1 (<1%)
Operational service overseas	16 (53%)
Operational service (WW2)	14/16 (87.5%)
Middle East/ European theatre of operations	11/14 (79%)
Pacific theatre of operations	3/14 (21%)

Table 1. Summary of demographic data

Medical Diagnosis	Number of residents with condition*
Ischaemic Heart Disease (IHD)	15 (50%)
Diabetes mellitus	15 (50%)
Mental illnesses	15 (50%)
Cerebrovascular disease/stroke	10 (33%)
Gout	9 (30%)
Essential Hypertension	8 (27%)
Osteoarthritis	8 (27%)
Chronic Obstructive Pulmonary Disease	7 (23%)
Prostate disease (benign and malignant)	7 (23%)

\* percentages do not total 100% as each resident had more than one medical co-morbidity

*Table 2. Most common medical conditions among study participants*

The most common medical problems among the study participants included ischaemic heart disease (IHD), diabetes mellitus, gout, chronic obstructive pulmonary disease (COPD), cerebro-vascular disease, and mental illnesses requiring medication (Table 2). An average of nine medications (range 3 to 18 medications) were taken regularly per individual in the study group with the most common classes of medication being antiplatelet agents, oral hypoglycaemics, nitrates, diuretics, beta-blockers, calcium channel blockers, tricyclic antidepressants and selective serotonin re-uptake inhibitors.

From a dental perspective, two thirds of the study group veterans were totally edentulous (20/30 veterans) and one quarter was partially dentate in both maxilla and mandible (8/30 veterans). Two veterans did not wear a lower denture by choice. Of the twenty veterans with dentures, seven had poor denture hygiene with calculus and heavy staining evident on examination (35%). One patient wore a dental implant-borne overdenture and was a patient of a university study at the School of Dentistry. All of the partially dentate patients had oral hygiene issues with two veterans having significant levels of calculus around their remaining dentition. Clinically evident dry mouth was noted in four veterans and one veteran suffered from intraoral mucositis secondary from chemotherapy.

Active dental treatment (restorative needs) were identified in two veterans and seven veterans were recommended to have a reline or a new set of dentures made. Only two of the study group complained of ill fitting or loose dentures. Of the thirty participating residents of Montecillo, only three veterans had regular access to a dental professional either through private practice or through the University of Otago School of Dentistry.

In the six months following the study period, nine of the thirty veterans have since died (30%).

## Discussion

New Zealand has a relatively short but proud overseas military history from the deployment of mounted riflemen to South Africa in 1899-1902 and through to the first and Second World Wars where, similar to our Australian counterparts, New Zealand's military forces earned a reputation for being first class fighting men. There are no surviving First World War veterans in New Zealand but significant numbers of veterans who fought in the Second World War still live in the community and often are residents of aged-care facilities, but these numbers too are dwindling. The next significant cohort of ageing veterans consist of those who served in Korea, Borneo, Malaya and Vietnam during the 1950's to 1970's.

The results of this pilot study give small insights into some of the unique issues that may have particular relevance in providing oral health care among such a veteran population. The strengths of this pilot study include the easy access to military veterans in a single aged-care facility that is dedicated to war veterans and the ability to review a complete residential medical file which includes a summary of their service record. Furthermore, this study has raised the profile of oral health at Montecillo and it has received unreserved support for its continuation. The weaknesses of the study however include the small numbers involved in the study population, and the limitations of a clinical examination in such a setting, which limits diagnosis to visual examination without radiographic interpretation. For denture wearers the treatment planning was more straight forward but for partially dentate individuals requiring restorative dentistry, a definitive treatment plan could not be established without further radiographic work up. From a longitudinal standpoint, the majority of the population may not be able to be followed for a long period of time due to advanced age and significant medical co-morbidities.

The residents of Montecillo appear to have similar oral health needs as other aged-care facility residents and share similar risk factors affecting oral and dental health. In our study two thirds of the residents were edentulous and the remaining one third retaining some or most of their natural dentition. This is consistent with findings from another New Zealand based study of 210 non-military veteran aged-care facility residents and may represent the high rate of edentulism that was commonly found in New Zealand adults during and after the Second World War. In contrast, only one third of institutionalised elderly patients were found to be edentulous in a study based in Montpellier, France<sup>3</sup>.

The majority of the residents at Montecillo did not have regular access to dental care and similar to aged-care facility residents world-wide, generally exhibited a poor level of oral health care in terms of prevention and maintenance. The obvious issues affecting oral health care provision are three-fold: limited ability to perform oral hygiene self-cares by the residents themselves, medical co-morbidities and inadequate training of aged-care facility staff. Aged-care residents commonly have decreased motor skills either due to neurologic problems or arthritic/joint problems limiting manual dexterity. This may be compounded by decreased cognitive function, deteriorating eyesight or progressive dementia; all leading towards a decreased ability to perform oral cares by the resident themselves. In conjunction with physical degeneration are the multiple medical issues that are encountered in this population and the polypharmacy used to manage their conditions.

In the Montecillo study group common medical problems that may affect the ability to perform self cares for oral hygiene include cerebro-vascular disease and stroke, arthritis and mental illnesses such as depression, post-traumatic stress disorder (PTSD) and alcoholism. Increased periodontal disease and dental caries are associated with diabetes mellitus and dry mouth, the latter being a result of degenerative salivary gland disorders or a common side effect of medications that may be taken on a daily or regular basis. Among the more common medications that produce dry mouth symptoms are tricyclic antidepressants, selective serotonin reuptake inhibitors, bowel or urinary bladder antispasmodics, cardiovascular medications (including diuretics, ACE-inhibitors, calcium channel blockers and beta-blockers) and histamine-2 receptor antagonists (for example ranitidine)<sup>11,12</sup>. A number of these medications were represented in this cohort of patients.

One study of 257 institutionalised elderly residents (mean age 83.7 years) found that of all the medical conditions examined in the study group, only psychiatric disorders were significantly related to poor oral health status<sup>10</sup>. The authors also found that low socio-economic status and the duration of institutionalisation were also closely related to poor oral health among their study population.

The lack of dedicated dental professional input into aged-care facilities places greater burden and onus on medical and nursing staff in those facilities. Medical practitioners may be able to screen for gross oral health problems and in conjunction with a dental health professional may help modify medications to decrease such side effects as dry mouth, but essentially the dental needs of these patients must ultimately be managed by dental professionals. Simple measures

such as in-service training or courses for nursing staff, clear oral hygiene protocols, clearly named dentures and denture hygiene instructions have been proposed to improve the provision of oral health by non-dental health care workers<sup>13,14</sup>. Similar to cardiovascular health issues, the fundamental starting points for oral health in this vulnerable population is prevention. In order to facilitate this however, a higher degree of oral health promotion and cooperation between dental, medical and nursing staff must be encouraged with clear individualised plans for each resident and regular assessment of dental needs and oral cancer screening. Formal educational programmes have also been advocated to raise awareness of oral health needs for both staff and residents alike<sup>15</sup>.

We have highlighted the generic problems encountered in providing oral health care in aged-care facility residents, but what specifically are the issues affecting war veterans? The issues already highlighted above affect all institutionalised elderly residents irrespective of war veteran status; however two areas should be given greater consideration, namely mental illness (including alcoholism) and service-related oral health conditions. Psychiatric disorders have been identified as having a negative impact on oral health status which may be related to motivation issues or medication effects such as dry mouth and psychomotor impairment. The lifetime prevalence of depression (major depressive disorder according to Diagnostic and Statistical Manual (DSM) –IV criteria, 1994) varies from 5-12% in men and 10-25% in women<sup>16</sup>. It has been reported that the overall prevalence of mood disorders does not vary according to race or ethnic group but according to the SHARE study (Survey of Health, Ageing and Retirement in Europe) conducted in ten European countries, depression is more common in France, Italy and Spain compared to non-Latin ethno-lingual countries such as Germany, Sweden and Greece<sup>17</sup>. One French study of 1873 non-institutionalised elderly individuals reported a lifetime prevalence of major depression at 26.5% and 30% for anxiety disorders, which emphasises mental illness as a significant problem among the elderly population<sup>18</sup>.

Post Traumatic Stress Disorder (PTSD) among war veterans is common and is increasingly an issue observed among recent United States war veterans from OPERATION IRAQI FREEDOM and ENDURING FREEDOM (Iraq and Afghanistan respectively) accessing their Veterans Administration hospital system<sup>19,20</sup>. One study of United States Second World War veterans who were prisoners of war (POWs) reported that 16.6% of their study group met criteria for PTSD with those serving in the Pacific having a three fold PTSD rate compared to their European theatre of war counterparts<sup>21</sup>. Furthermore, a study of 240 Balkans

Conflict (Bosnia) veterans reported a higher degree of aggression among war veterans with PTSD who also had co-morbid alcoholism when compared to veterans with PTSD who did not have alcohol issues<sup>22</sup>.

In our pilot study group of thirty residents, fifteen residents had mental illness diagnoses (50%) including eleven residents with depression (11/15 or 73%) and three with dementia.

Four individuals were also considered as high risk for alcohol abuse. Only one resident in the study group of thirty had a formal diagnosis of PTSD (3%) which is similar to the 3.4% reported in a German based study of PTSD among a general population of 60 years and older<sup>23</sup>. With regard to service-related oral conditions, each country will have different criteria and levels of compensation related to war pension benefits. This is an obvious difference between military veterans and other elderly individuals who do not have this source of funding opportunity for oral health care. However, the examining health professional must be able to link oral health status and the period of military service during which oral health was affected. This may range from obvious interventions as removing all the dentition to render a soldier “dentally fit” (as was commonly done for New Zealand soldiers prior to deployment during the First World War) to linking periodontal disease from long periods of poor oral hygiene (such as soldiers in South East Asia on lengthy jungle patrols). The awareness that service conditions may have contributed to oral health issues is another important facet in providing oral health care for a veteran population and may be overlooked during a dental assessment.

### Conclusion

The oral health care needs of a veteran population do not differ greatly from the needs of other non-veteran aged-care facility residents but greater consideration should be given during assessment for possible service-related oral conditions and mental illness issues including PTSD and alcohol abuse.

This pilot study has highlighted a greater need for dental input in this population group and for educational opportunities for nursing staff caring for these individuals. Further longitudinal data from Montecillo and potentially other war veteran rest homes in New Zealand should be collected for future comparison in order to emphasise the importance of oral health care as part of an integrated and holistic health management plan for these individuals.

### Acknowledgements

The authors wish to thank the Board of Trustees, the CEO, the nursing staff and residents of Montecillo for their support and willingness to participate in this study.

---

*Authors' affiliation: University of Otago, Dunedin, New Zealand  
Corresponding author: Mr Darryl Tong, Consultant Oral and Maxillofacial Surgeon, Dept of Oral Diagnostic and Surgical Sciences, University of Otago, Dunedin, NZ.  
PO Box 647, Dunedin 9054, New Zealand.  
Email: darryl.tong@otago.ac.nz*

### References

1. Lo EC, Luo Y, Dyson JE. Oral health status of institutionalised elderly in Hong Kong. *Community Dent Health* 2004; 21: 224-6.
2. Greene VA. Underserved elderly issues in the United States: Burdens of oral and medical health care. *Dent Clin N Am* 2005; 49: 363-376.
3. Montal S, Tramini P, Triay JA, Valcarcel J. Oral hygiene and the need for treatment of the dependent institutionalised elderly. *Gerodontology* 2006; 23: 67-72.
4. Sweeney MP, Williams C, Kennedy C, MacPherson LM, Turner S, Bagg J. Oral health care and status of elderly care home residents in Glasgow. *Community Dent Health* 2007; 24: 37-42.
5. Antoun JS, Adsett LA, Goldsmith SM, Thomson WM. The oral health of older people: general dental practitioners' beliefs and treatment experience. *Spec Care Dentist* 2008; 28: 2-7.
6. Stockwell AJ. Survey of oral health needs of institutionalised elderly patients in Western Australia. *Community Dent Oral Epidemiol* 2006; 15: 273-6.
7. Weyant RJ, Jones JA, Hobbins M, Niessen LC, Adelson R, Rhyne RR. Oral health status of a long term care, veteran population. *Community Dent Health* 1993; 21: 227-233.
8. Ettinger RL. The unique oral health needs of an aging population. *Dent Clin N Am* 1997; 41: 633-49.
9. Carter G, Lee M, McKelvey V, Sourial A, Halliwell R, Livingston M. Oral health status and oral treatment needs of dependent elderly people in Christchurch. *NZ Med J* 2004; 21: 117(1194):U892.
10. Kossioni AE, Karkazis HC. Socio-medical condition and oral functional status in an older institutionalised population. *Gerodontology* 1999; 16: 21-8.
11. Paunovich ED, Sadowsky JM, Carter P. The most frequently prescribed medications in the elderly and their impact on dental treatment. *Dent Clin N Am* 1997; 41: 699-726.
12. Williams BR, Kim J. Medication use and prescribing considerations for elderly patients. *Dent Clin N Am* 2005; 49: 411-27.
13. Hoad-Reddick G. A study to determine oral health needs of institutionalised elderly patients by non dental health care workers. *Community Dent Oral Epidemiol* 1991; 19: 233-6.
14. MacEntee MI. Caring for elderly long term care patients: oral health related concerns and issues. *Dent Clin N Am* 2005; 49: 429-443.
15. Erickson L. Oral health promotion and prevention for older adults. *Dent Clin N Am* 1997; 41: 727-750.
16. Kaplan HI, Sadock BJ. *Synopsis of Psychiatry*, 8th edition. Philadelphia: Lippincott Williams and Wilkins, 1998, pp524-525.
17. Castro-Costa E, Dewey M, Stewart R, Banerjee S, Huppert F, Mendonca C et al. Prevalence of depressive symptoms and syndromes in later life in ten European countries. *Br J Psychiatry* 2007; 191: 393-401.
18. Ritchie K, Artero S, Beluche I, Ancelin ML, Mann A, Dupuy AM et al. Prevalence of DSM-IV psychiatric disorder in the French elderly population. *Br J Psychiatry* 2004; 184: 147-152.
19. Seal KH, Maguen S, Cohen B, Gima KS, Metzler TJ, Ren L et al. VA mental health services utilization in Iraq and Afghanistan veterans in the first year of receiving new mental health diagnoses. *J Trauma Stress* 2010; 23: 5-16.
20. Jakupcak M, Tull MT, McDermott MJ, Kaysen D, Hunt S, Simpson T. PTSD symptom clusters in relationship to alcohol misuse among Iraq and Afghanistan war veterans seeking post deployment VA health care. *Addict Behav* 2010; doi: 10.106/j.addbeh.2010.03.023
21. Rintamaki LS, Weaver FM, Elbaum PL, Klama EN, Miskevics SA. Persistence of traumatic memories in World War II prisoners of war. *J Am Geriatr Soc* 2009; 57: 2257-62.
22. Babic D, Martinac M, Bjelanovic V, Babic R, Sutovic A, Sinanovic O. Aggression in war veterans suffering from posttraumatic stress disorder with co-morbid alcoholism. *Coll Antropol* 2010; 34 suppl 1: 23-8.
23. Glaesmer H, Gunzelmann T, Braehler E, Forstmeier S, Maercker A. Traumatic experiences and post-traumatic stress disorder among elderly Germans: results of a representative population based study. *Int Psychogeriatr* 2010; 22: 661-70 (Epub 31 Mar 2010)

# Neurology in Aviation

Prof Roy G. Beran, M.D, FRACP, FRCP

## Abstract

Preparing an overview of neurology in aviation starts with a review of the Civil Aviation Safety Authority (CASA) guidelines. The CASA guidelines cover a range of neurological conditions such as: headaches; syncope and seizures; disequilibrium; degenerative diseases; and peripheral neuropathy. Trauma and post-traumatic amnesia are discussed, as is neurosurgical management. The role of routine neurophysiologic testing, such as electroencephalography, is appraised and seizure receives further attention beyond the CASA rules. Other pathophysiological factors are also examined to complete the overview and to serve as a basis upon which to evaluate aircrew, determine fitness to fly and offer support for ADF flying operations.

## Introduction

When asked by RAAF Edinburgh to provide an overview of neurology in aviation for the aviation medical officer (AVMO) course and the AVMO refresher course, the magnitude of the task was more than evident.

The aim of the course is "... to prepare ADF medical officers and civilian health practitioners in order to provide aviation medical services to the ADF as AVMOs. This includes clinical management of aircrew, determination of fitness to fly and medical support to ADF flying operations ...". While it is accepted that aircrew in the ADF must achieve the accepted standards relevant to all aircrew, it is necessary to recognise that they may function within a much more hostile environment, as may occur in theatres of war or may be relevant to flying more sophisticated fighter planes, thereby necessitating additional considerations beyond those relevant to normal pilots.

Time allocation for the overview was 1½ hours, which really only permitted the broadest of overviews. Hence it was felt appropriate to offer a summary of the presentation to *Journal of Military and Veterans' Health* to capitalise on the research undertaken and to offer as comprehensive an overview as time and space would allow. The content of this paper does not specifically address many of the additional factors that are relevant to aviation within ADF operations, which may enforce more rigorous restrictions and expectations upon aircrew.

What follows is that overview of 'Neurology in Aviation'.

## CASA Guidelines

It seemed appropriate to commence such an overview with a review of the Civil Aviation Safety Authority (CASA) Guidelines<sup>1</sup>. Topics covered in the Guidelines included: headache; blackouts; loss of consciousness and syncope; disequilibrium; seizures; head injuries; neurosurgery; cerebral infarcts; infections; dementia and degenerative diseases; extra-pyramidal diseases; demyelination; tumours and peripheral neuropathy<sup>1</sup>. This clearly reads like a textbook of neurology and to do it full justice would be well beyond the scope of an overview such as this. What follows will offer a succinct summary of the contents of the Guidelines.

CASA has adopted an approach to headache which favours a continuum of headache with tension-type headache at one end of the spectrum and migraine at the other. This is a concept favoured by the author<sup>1,2</sup>. What must be distinguished are primary headaches from secondary headaches, consequent to other causes, such as neuralgia, tumours or arteritis. A proper history defining quality of headaches, exacerbating and relieving factors, frequency, evolution, associated features, such as photophobia, phonophobia, visual symptoms, paraesthesia, severity and effectiveness of therapy are important deciding factors. It is important to distinguish migraine from transient ischaemic attack and also acknowledge the potential for migraine-induced stroke. CASA will consider each person on his/her merits and does not impose any blanket restriction due to diagnosis of headache<sup>1</sup>.

It is recognised that terms such as 'blackout', 'loss of consciousness' and 'syncope' are open to interpretation in differentiating altered state of consciousness from vertigo, hysterical fugues, concussion, transient global amnesia or simple loss of vision. History is imperative and it is mandatory to try to differentiate neurological from cardiological causes. Again CASA assesses each case individually and advocates appropriate consultant involvement<sup>1</sup>.

Disequilibrium may include benign paroxysmal positional vertigo (BPPV), acute peripheral vestibulopathy, Meniere's Disease and acute recurrent positional vestibulopathy (ARPV), alternative vertigo, momentary vertigo or non-functioning/hypo-functioning labyrinthitis, vestibular imbalance or multi-sensory dizziness. CASA maintains an individual response based on diagnosis and responsiveness

to treatment. CASA also advises that treatment for disequilibrium may provoke drowsiness, which may itself be unacceptable for pilots<sup>1</sup>.

When considering seizures, CASA has demonstrated flexibility stating "...tendency towards epileptic seizures is not an 'all or nothing' phenomenon. Most people, under certain conditions, may have a seizure if sleep deprived or withdrawing from alcohol or benzodiazepines, especially if in addition they are taking medications that decrease the seizure threshold..."<sup>1</sup>. CASA accepts 2% of the population will have a seizure and 30 – 40% of adults have a chance of recurrence after a single seizure<sup>1</sup>. Some research has suggested even higher prevalence figures for epilepsy, namely a tendency to recurrence of seizures, itself approaching 2%<sup>3</sup>.

The aeromedical certification considerations concerning epilepsy require specialist neurological opinion; consideration of provocateurs; unavoidable concomitants of aviation (such as strobe lights, propeller flicker, fatigue, recognising that photically-induced seizures occur in  $\leq 15\%$  of people with epilepsy<sup>4</sup>, difficult to avoid provocateurs such as menstruation (in association with catamenial epilepsy<sup>5</sup> and avoidable or insignificant provoking factors in the context of aviation, such as alcohol excess and/or withdrawal and sleep<sup>1</sup>. Individuals with established epilepsy, defined by CASA as experiencing  $>1$  unprovoked seizure, are considered unfit for aviation medical certification. Those "...who have experienced seizures but who are not diagnosed as epileptic may be deemed to meet the medical standard..."<sup>1</sup>.

CASA identified some special circumstances which include: partial seizures; sleep (nocturnal) epilepsy; childhood seizures; and single epileptiform seizures and deals with each of these separately<sup>1</sup>. As the involvement of a neurologist is mandatory in these cases – further discussion is unnecessary within the context of this overview.

The two concerns identified by CASA as relevant to head trauma, re fitness for aviation related duties, are the possible neuropsychological consequences and potential for post-traumatic epilepsy (PTE). The neuropsychological consequences result from acceleration/deceleration forces causing "...focal damage...to orbital, frontal and anterior temporal areas of the brain. Diffuse white matter damage may be associated with the cortical damage..."<sup>1</sup>. CASA has identified potential deficits in executive functioning regarding reaction times; memory impairment; decreased endurance of higher intellectual function; mental decline and fatigue; impaired attention span; diminished propensity to initiate or sequence activities; decreased capacity for planning; or ambivalence to performance level. CASA has recognised the possibility of subtle deficits with retained intellectual

quotient and mental status that necessitate special neurophysiological assessment. It is also acknowledged that there is potential for these deficits to improve with time<sup>1</sup>.

Duration of post-traumatic amnesia (PTA) received special attention, with PTA  $<1$  hour resulting in suspension from aviation-related duties for 1 month; PTA of (1) – 24 hours causing 3 months suspension; and PTA  $> 24$  hours resulting in suspension for at least 1 year<sup>1</sup>.

Childhood febrile convulsions and/or a family history of epilepsy doubles the risk associated with any other markers for PTE<sup>1</sup>. PTE within the first week after trauma carries a 25% risk of later epilepsy<sup>1</sup> while overt convulsive activity immediately on impact does not increase the risk, although post-immediate convulsions are classed as 'early PTE'. Intracerebral haemorrhage, especially cortical, is associated with 25 – 45% risk of PTE<sup>1</sup>. Proper evaluation is essential, including imaging – preferably with MRI, but after the first week (period of 'early PTE') the risk declines exponentially such that by 2 years it is 20% of initial risk, by 4 years it is 10% and CASA accepts a risk of 1% for PTE to allow recertification<sup>1</sup>.

Those sequelae most commonly resulting in failed assessment include: "...epilepsy; intracerebral haematoma; persisting CSF fistula; primary open cerebral laceration and the presence of any significant persistent neurological deficit..."<sup>1</sup>. Guidelines for recertification, as set out within the CASA guidelines, are considerably more restrictive than appears to be the case when reviewing the above rules<sup>1</sup> and include:

1. PTA  $\leq 30$  mins without sequelae and normal neurological examination may return to full duties in 3 – 4 months if CT is normal.
2. PTA  $\frac{1}{2}$  - 24 hours with normal MRI and EEG are acceptable after 1 year unless there was early PTE, which dictates individual assessment.
3. PTA  $> 24$  hours with all else normal are fit after 2 years but may require flight stimulator testing.
4. Head injuries with intracerebral bleeds or focal deficits without significant neuro-psychologically proven deficits at 5 – 7 years post-trauma may resume duties after 7 years. Those with neuropsychological deficits will be assessed individually and MRI is required to evaluate bleeding.
5. Anti-epileptic medications (AEM) may mask PTE, hence seizure-free period only starts after AEM use has ceased and if still deemed at risk of seizures ( $>1\%$ ) then the person remains unfit<sup>1</sup>.

Neurosurgery assessment is based on underlying disease and its prognosis; neurological deficits; type of

surgery performed; risk of post-surgery epilepsy; and location thereof. All cases start as “doubtful” thereby necessitating individual approach<sup>1</sup>.

Cerebrovascular disease necessitates consultant involvement and specialist opinion, which is beyond the scope of this review<sup>2</sup>, which is also the case for central nervous system (CNS) infection (recognising that CASA imposes at least 6 months exclusion for both meningitis and encephalitis<sup>1</sup>. Dementia attracts special attention<sup>1</sup> and where there is doubt or discrepancy between reported and observed function then functional assessment is required and comparison with earlier testing may be helpful. Where dementia is considered progressive, “..an immediate “fail” assessment is likely ...”<sup>1</sup>.

Extrapyramidal disease (Parkinsonism) and demyelination (multiple sclerosis) necessitate consultant involvement in management and thus are largely outside the scope of this overview. Parkinsonism does not necessitate immediate exclusion but may demand more frequent assessment to monitor disease progression with a minimum of annual review and possible restriction of licence to “as or with co-pilot”<sup>1</sup>. Cases of multiple sclerosis are individually assessed with regular neurological review<sup>1</sup>. Intracranial tumours and peripheral nerve disease also mandate specialist opinion with the at risk peripheral disease being dysautonomia, which may cause syncope and is incapacitating<sup>1</sup>.

### Causes for pilot disqualification

In the past the most common cause for pilot disqualification was cardiological, which accounted for more than double that of neurology (0.59/1,000 pilot years of 0.26/1,000 pilot years for neurological causes, 0.20/1,000 pilot years for psychiatric disorders)<sup>6</sup>. More recent data to emerge from Norway<sup>7</sup>, with comprehensive data ascertainment incorporating 48, 229 pilot years, identified 275 who were permanently disqualified. The most common cause for such disqualification was neurological, bypassing cardiological and hence emphasising the need for the current review.

The rate of disqualifications due to cardiological disease declined after 1997, most likely because of improved ‘evidence-based’ approach to regulation, which reflects the significant advances in treatment and follow-up. Pilots with coronary bypass surgery may now return to unrestricted flying duties. The majority of those disqualified because of neurological disorders were disqualified due to CNS disorders often based on abnormal findings using neuropsychological tests<sup>7</sup>.

### Neurophysiological Tests

There are those who advocate use of routine electroencephalography (EEG) to screen prospective pilots even if they are asymptomatic<sup>8</sup>. Others challenge this approach<sup>9</sup>. The USAF stopped use of routine EEG screening in 1978, the USN stopped in 1981 and NASA stopped in 1995<sup>9</sup>.

Various studies have cast doubt on the predictive value of EEGs<sup>10-14</sup>. When testing 28,658 student naval aviation personnel, 31 had potentially diagnostic epileptic EEGs, of whom 1 had a seizure, compared with 4 who had a seizure from the 28,627 with normal studies. This confirms both false positives and negatives, raising concerns as to cost effectiveness<sup>11</sup>. A prospective six-year study of EEGs in military pilots cast further doubt on its cost effectiveness<sup>14</sup>.

### Seizures, Epilepsy and Flying

US standards for commercial pilots diagnosed with epilepsy determines that they are automatically excluded from commercial flying. A private pilot may be recertified depending on certain circumstances with individual case assessment. The US may allow general aviation if the pilot has had a single seizure, was subsequently seizure free for 10 years and off all AEM<sup>15</sup>.

The fact that a patient has a single seizure does not automatically generate a diagnosis of epilepsy. Moniago & Griswold<sup>16</sup> reported the case of a seizure occurring consequent to normobaric hypoxic training in association with sleep deprivation and failure of re-oxygenation (namely failure to adequately absorb oxygen) with application of 100% oxygen (oxygen paradox). The student, a day later, had normal neurological examination with two normal EEGs and a normal MRI of the brain.

Analysis of this case highlighted various factors related to seizures and capacity to return to flying<sup>16</sup>. These included: “..likelihood of incapacitation during flight; the severity of such an episode; the crew member’s function in the aircraft; and the demands of the aviator’s particular type/model of aircraft”. A practitioner of aviation medicine must weigh severity and risk in determining an aviator’s fitness for return to duties involving flight (16 at 488).

In the case described, the patient was an electronic countermeasures officer within a multi-seat aircraft rather than its pilot<sup>16</sup>. Based on full analysis, the case was deemed a provoked seizure based upon physiologic compromise with a low recurrence risk allowing the officer to resume full duties<sup>16</sup>.

### Pathophysiological Factors

Clinical neurology is usually practised in a normal environment (at one atmosphere of pressure) in circumstances of 21% oxygen and 78% nitrogen<sup>17</sup>. As demonstrated in the above-cited case<sup>16</sup> other environments have the capacity for toxic complications.

Aviation conditions can alter the normal environment due to hypoxia (gas at decreased pressure - also referred to as hypoxic or hyperbaric hypoxia), acceleration (affecting the vestibular apparatus) and volume effects from changes in ambient pressure that can be either gradual or rapid with the latter causing decompression.

The CNS is vulnerable to reduced oxygenation from a number of potential causes. These include: histotoxicity, hyperaemia hypoxia, stagnation or "stagnant hypoxia" or hypoxia with deficient alveoli oxygenation. Each of these terms warrants definition. Histotoxicity occurs when cells cannot use delivered oxygen due to dysfunction of the cytochrome oxidase system as may occur with cyanide exposure. Hyperaemia hypoxia relates to decreased capacity of red cells to carry oxygen as may occur with anaemia or carbon monoxide poisoning. Stagnation, or "stagnant hypoxia" occurs with inadequate blood flow as may occur with deceleration forces. Hypoxia with deficient alveoli oxygenation and ventilation/perfusion mismatch may occur with altitude which causes decreased pressure and air density.

Hypoxia may produce tunnel or blurred vision, fatigue, drowsiness and headache<sup>17</sup>. It may also produce confusion, altered behaviour, inco-ordination and loss of consciousness and even seizures<sup>16</sup>. A pilot may not recognise the effects of hypoxia, but if aware, then supplemental oxygen is required especially if above 10,000 feet altitude. If this is not possible then descent below 10,000 feet may be required.

Acceleration causing "G" forces, especially +Gz (eyeballs-down), may produce reduced vision and loss of consciousness (G-LOC) due to decreased retinal and brain perfusion consequent to blood pooling in the lower limbs<sup>17</sup>. This hydrostatic effect has particular relevance and is most important in military aviation with the blood pooling being a later phenomenon.

The sequence is impaired peripheral vision (with PaO<sub>2</sub> <50 mmHg) to loss of central vision and blackout (with PaO<sub>2</sub> ≤20). With loss of consciousness, 70% will experience myoclonus (as occurred in the case report<sup>16</sup>). The EEG shows slowing with delta activity rather than epileptiform discharges<sup>17</sup>.

Air emboli may result with 5% air emboli entering cardiac vessels and 95% travelling to cerebral vessels. Hyperbaric recompression and IV fluid therapy is indicated, as for decompression illness<sup>17</sup>. This is an issue for rapid decompression from high altitude (typically 25 k plus).

### Conclusion

Full evaluation of neurology in aviation demands a detailed overview of most of neurology, which is both impracticable and largely impossible within this brief review. The salient features of the CASA Guidelines have been provided in support of the fact that neurological diagnoses present the most common cause for disqualification of pilots and aircrew. Routine neurophysiologic testing of asymptomatic flight candidates is non-cost-effective with both false positives and false negatives. Such tests should be limited to specific cases in which the clinical picture warrants further appropriate investigations. Seizures per se need not exclude flying duties, depending upon the diagnosis of epilepsy, the type of epilepsy and provocation. As with so many neurological diagnoses, the involvement of a consultant neurologist is a mandatory part of the patient evaluation. Just as hypoxia may result in a seizure, so too will neurology in aviation demand an understanding of the effects of pressure changes on neurological function.

---

*Author's affiliation: University of New South Wales, NSW  
Contact author: Prof Roy G. Beran, M.D, Conjoint Associate  
Professor University of New South Wales, Suite 5, Level  
6, 12 Thomas Street, Chatswood, NSW, 2067, Australia.  
Email: research@royberan.com*

### References

1. Civil Aviation Safety Authority *Designated Aviation Medical Examiner's Handbook - 2 Medical Aspects – 2.5 Neurology* – Approved by Assistant Director Aviation Safety Standards – Version 3.0, Dec 2003, Australian Govt, Canberra pp 2.5 (1 – 26)
2. Beran R G “Headache” *Medical Observer* 2008; May: 31 – 33
3. Beran R G, Hall L, Michelazzi J “An accurate assessment of the prevalence ratio of epilepsy adequately adjusted by influencing factors” *Neuroepidemiology* 1985; 4:71-81
4. Erba G “Preventing seizures from “Pocket Monsters” – A way to control reflex epilepsy” *Neurology* 2001, 57 (10): 1747 - 1748
5. Quigg M, Smithson S D, Fowler K M, Sursal T, Herzog A G, “NIH Progesterone Trial Study Group Laterality and Location Influence Catamenial Seizure Expression in Women with Partial Epilepsy” *Neurology* 2009; 73 (3): 223 – 227
6. McCrary B F, van Syoc D L “Permanent flying disqualification of USAF pilots and navigators (1995 – 1999)” *Aviat Space Environ Med* 2002; 73: 1117 - 21
7. Arva P, Wagstaff A S “Medical disqualification of 275 commercial pilots: Changing patterns over 20 years” *Aviat Space Environ Med* 2004; 75: 791 - 4
8. Hendrickson I J M, Elderson A “The use of EEG in aircrew selection” *Aviat Space Environ Med* 2001; 72: 1025 - 33
9. Clark J B, Riley T L “Screening EEG in aircrew selection: Clinical aerospace neurology perspective” *Aviat Space Environ Med* 2001; 72: 1034 - 6
10. King W H, Liske E “Electroencephalogram and aerospace safety” *Aerosp Med* 1974; 44: 90 - 1
11. Le Tourneau D J, Merren M D “Experience with electroencephalography in student naval aviation personnel 1961 – 1971: A preliminary report” *Aerosp Med* 1973; 44: 1302 – 4
12. Robin J J, Tolan G D, Arnold J W “Ten year experience with abnormal EEGs in asymptomatic adult males” *Aviat Space Environ Med* 1978; 49: 732 – 6
13. Everett W D, Akhovi M S “Follow of 14 abnormal electroencephalograms in asymptomatic US Airforce Academy Cadets” *Aviat Space Environ Med* 1982; 53: 277 - 80
14. Everett W D, Jenkins S W “The aerospace screening electroencephalogram: An analysis of benefits and costs in the US Air Force” *Aviat Space Environ Med* 1982; 53: 495 - 501
15. Drazkowski J F “Driving and flying with epilepsy” *Current Neurol. Neurosc Reports* 2007; 7: 329 – 34
16. Moniaga N C, Griswold C A “Loss of consciousness and seizure during normobaric hypoxic training” *Aviat Space Environ Med* 2009; 80: 485 - 488
17. Jaffee M S “The neurology of aviation, underwater and space environments ” *Neurol Clin* 2005; 23: 541 – 52

# Paediatric aeromedical transport and hypoxia

Jeffrey C Stephenson OAM MBBS MAvMed DipAeroRet

## Introduction

Paediatric patients have different anatomical and physiological parameters when compared to the adult population. These differences are consistent and well described<sup>1</sup>, with some of them rendering the infant more susceptible to hypoxia<sup>2</sup>. Aeromedical staff require a sound knowledge of these differences to properly treat the paediatric patient.

## Paediatric anatomy and physiology

### Paediatric body mass and morphology

Paediatric patients have lower body mass, less fat and connective tissue, and are morphologically different to adults<sup>1</sup>. In addition, their vital organs are in close proximity to the skin and the head is proportionally larger. The surface area to volume ratio is highest at birth and decreases as the child grows. This high ratio results in greater loss of thermal energy, and the paediatric patient is more prone to hypothermia<sup>1</sup>.

### Respiratory

Paediatric patients also have significantly different respiratory parameters to adults. They have higher respiratory rates, ranging from 40 to 60 breaths per minute in the infant, whereas an older child breathes 20 times per minute<sup>1</sup>. Spontaneous tidal volumes vary from six to eight mL/kg<sup>1</sup>. For the apnoeic child, mechanical ventilation is required and in this case tidal volumes are between 10 to 15 mL/kg and the minute volume is approximately 100mL/kg/min<sup>3</sup>. The paediatric patient also has an immature tracheobronchial tree. The developing respiratory system is relatively fragile and more prone to barotrauma than the adult. Hypoxia is the commonest cause of cardiac arrest in the child<sup>1</sup>.

### Cardiovascular

The circulating blood volume of the child is also different to the adult. The child has a circulating blood volume of approximately 80ml/kg, whereas in the adult it is 70 ml/kg<sup>1</sup>. The increased physiologic reserve of the paediatric patient allows for preservation of most vital signs in the normal range, even when the child is shocked<sup>1</sup>. Pulse rates up to 160 may be normal in the neonate. This figure decreases with age until it drops below 100 by the onset of adolescence.

## Other considerations

Venous access is more difficult to achieve in the paediatric patient, and must always be secured prior to emplaning. The retrieval team should also be aware that the infant urinary output is higher than that of the adult. (2.0 mL/kg/hr in the infant decreasing to 1.0mL at age three to five years, and 0.5mL by adolescence<sup>1</sup>). Paediatric patients also have different psychologic needs when compared to adults.

## An increased susceptibility to hypoxia

The anatomical and physiological differences between infants and adults are marked, and the response to the hypoxic environment encountered during flight is different<sup>3</sup>. The susceptibility to hypoxia is most marked in newborns and infants in the first year of life. Table 1 contains a summary of the factors increasing the susceptibility of infants and young children to hypoxaemia.

### Hypobaric hypoxia of aeromedical retrieval

Atmospheric pressure falls in an approximately exponential manner with increasing altitude<sup>2</sup>. With increasing altitude there will be a corresponding decrease in barometric pressure. The barometric pressure at Mean Sea Level (MSL) in standard atmospheric conditions is 760mmHg, and this falls to 565mmHg at 8,000feet<sup>2</sup>. Dalton's Law of Partial Pressures states that each gas in a mixture exerts the same pressure as if it were present, alone, in the same volume<sup>3</sup>. Oxygen partial pressure (PO<sub>2</sub>), or oxygen tension, is the portion of the total pressure that is exerted by the oxygen alone. The PO<sub>2</sub> difference between two areas determines the direction and rate of flow (diffusion) of oxygen molecules, including when the oxygen is in solution. A PO<sub>2</sub> gradient exists in different locations within the respiration cycle, allowing oxygen flow to occur, from regions with higher levels of PO<sub>2</sub> to regions with lower levels of PO<sub>2</sub> – this is called the oxygen cascade<sup>2</sup>.

At the maximum cabin altitude of 8,000 feet, the atmospheric pressure is 565mmHg, giving an atmospheric PO<sub>2</sub> of 118 mm Hg. This is equivalent to reducing the fraction of inspired oxygen (FiO<sub>2</sub>) at sea level to 15.5%. It can be seen that many of the anatomical and physiological parameters observed in the infant predispose them to an increased tendency to ventilation-perfusion mismatch. This results in infants being particularly susceptible to hypoxaemic episodes<sup>4</sup>.

Anatomical or Physiological parameter	Mechanism of hypoxaemia
Reduced surfactant - preterm	Atelectasis and hypoxia
Rib cage more compliant	Less support of lung volume - more marked during sleep
	Negative intrathoracic pressures are less effective for inspiring air
Predisposition for paradoxical inhibition of respiratory drive < 2 months of age	Infections and hypoxia may present with apnoeic episodes and hypoventilation
Increased proportion of muscular arterioles in the pulmonary vascular bed (early infancy)	Airway or alveolar hypoxia causes pulmonary vasoconstriction <sup>4</sup> (Hypoxia may arise from hypobaric hypoxia, chest infection or chronic lung disease)
	Rise in pulmonary vascular resistance contributes to right to left shunting, ductal opening (in the early neonatal period), further ventilation-perfusion mismatch, and hypoxia
Increased airway reactivity in response to hypoxia (infancy)	Airway or alveolar hypoxia in infants can cause bronchoconstriction <sup>5,6</sup>
	Infants at 26 weeks of age show greater desaturation on histamine challenge than infants 4 weeks old <sup>7</sup>
Lung volume at end expiration similar to closing volume <sup>8</sup> (early infancy)	Small airway closure, and hence non-ventilated units, occur more readily, e.g. during active sleep, feeding, and crying
Reduced upper and lower internal diameters of the airways	Airway conductance falls from birth to 2 months of age <sup>9</sup>
	Reduction in diameter reduces airway patency sooner <sup>10</sup> e.g. respiratory infection
Fewer alveoli (early childhood)	Growth in the alveolar region greater than that in the airways in early infancy <sup>11</sup> Increases the susceptibility to mismatch between ventilation and perfusion
Foetal haemoglobin present up until 3 to 6 months of age	Oxygen dissociation curve is shifted to the left, so oxygen is given up less readily to the tissues. For a given PO <sub>2</sub> , the SaO <sub>2</sub> is higher

Table 1: Factors increasing the susceptibility of infants and young children to hypoxaemia. Based on: Samuels M. The effects of flight and altitude. Archives of Disease in Childhood 2004;89:448-455 Table 2.

Level of respiration cycle	PO <sub>2</sub> Sea level	PO <sub>2</sub> 8,000 feet
Ambient air	160	118
Inspired (tracheal)	148	108
Alveolar	103	64
Arterial	95	56
Capillary	51	30
Mitochondrial	1-10	1-5

Table 2: The Oxygen Cascade showing the PO<sub>2</sub> at different stages of the respiratory cycle, in the resting subject breathing dry air: at Sea level – atmospheric pressure 760mmHg; and, 8,000feet – atmospheric pressure 565mmHg. Adapted from Ernsting, Nicholson, Rainford. Aviation Medicine 4th edition. Hodder Arnold 2006. Fig 2.14 p39, Table 3.2 p 45, Table 31.13 p 501.

Respiratory considerations during aeromedical retrieval of the infant

Decreased surfactant

Pre-term infants will often have decreased levels of lung surfactant predisposing to atelectasis. Atelectasis

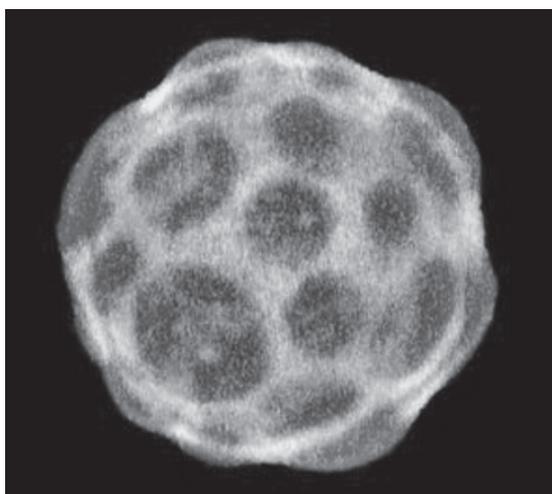
decreases ventilation, leading to a ventilation-perfusion mismatch and hypoxia<sup>2</sup>. Positive end-expiratory pressure may be necessary to overcome the tendency to atelectasis. Aeromedical transfer of the neonate should be performed using dedicated equipment suited to the physiology and anatomy of the newborn. In particular ventilators should have parameters that are appropriate for the patient, including safety valves to prevent pulmonary barotrauma during assisted ventilation.

Increased rib cage compliance

Neonates and young children display increased rib cage compliance<sup>2</sup>. Negative intrathoracic pressure generated during caudal diaphragmatic excursion is thus less effective at inspiring a volume of air. This is because the negative pressure generated is partly offset by a slight decrease in ribcage volume. Aeromedical staff should also be aware that infants predominantly use their diaphragm for respiration.

Paradoxical inhibition of respiratory drive

In infants younger than one to two months of age, the normal stimulus to ventilation caused by hypoxia



*Figure 1: Fluorescent microscopy of lung surfactant. The lipid from the lung forms a liposome with bulges. The diameter of the liposome is approx. 17µm. Fluorescent microscopy by Professor Luis Bagatolli Membrane Biophysics and Biophotonics group, University of Southern Denmark.*

is sometimes followed by paradoxical inhibition of respiration<sup>2</sup>. Infants, who may have a tendency to become hypoxic due to prematurity or concurrent lung infection, may display hypoventilation or apnoea when exposed to hypobaric hypoxia during aeromedical transfer. Therefore, it is vitally important in very young infants that the aeromedical staff ensure their patient is not exposed to hypobaric hypoxic conditions. Methods to minimise this would include: the use of supplemental oxygen to increase the  $\text{FiO}_2$ , the maintenance of a sea-level cabin pressure, and by ensuring there are no intervals of disconnection of supplemental oxygen - especially when emplaning and deplaning the neonate.

Increased preponderance of muscular arterioles in pulmonary vasculature

Exposure to hypoxic conditions, such as those encountered during aeromedical transfer will result in vasoconstriction of the pulmonary vessels<sup>4</sup>. In early infancy this leads to a marked decrease in perfusion of the respiratory system. The raised pulmonary vascular resistance may lead to increased right to left shunting through a patent foramen ovale, resulting in non-oxygenated blood returning to the systemic circulation. In addition, exposure to hypoxia during flight may prolong the patency of the ductus arteriosus<sup>3</sup>.

Increased airway reactivity in response to hypoxia

Some infants display increased airway reactivity when exposed to hypoxic conditions<sup>5,6</sup>. This reactivity actually increases following birth, to the point where at 26 weeks of age an infant shows greater desaturation upon histamine challenge when compared to a

four week old neonate<sup>7</sup>. Aeromedical transfer of an infant with bronchiolitis (which is characterised by bronchoconstriction) is thus made particularly hazardous if the infant is exposed to hypoxia. For this reason hypoxic exposure should be minimised as much as possible.

End expiratory lung volume approximates closing volume

Closing volume (CV) is the volume of gas in the lungs in excess of the residual volume (RV) at the time when small airways in the dependent portions of the lungs close during maximal exhalation. The closing capacity (CC) is equal to CV plus RV. The closing volume is greater in young children in whom the elastic supporting structure of the lung is incompletely developed. Infants are at greater risk for atelectasis as airway closure can occur even during tidal breathing<sup>15</sup>. A complete explanation can be found in Fact Box A<sup>6, 16</sup>.

**Fact box A - Closing volumes and the alveolar unit**

The existence of an air volume maintained within an alveolus is dependant on that unit obeying the laws of physics. The ambient pressure within the alveolus must be greater than the opposing combined forces of surface tension and elastic stretch of the alveolar tissue. Surface tension increases as the distance between adjacent alveolar cells decreases. (The tension force is inversely proportional to the square of the alveolar radius). If the alveolar walls are very close, such as occurs in end expiration, the surface tension may be high enough to effect closure (via apposition) of some alveolar units. In other words, if the end expiratory lung volume is low enough some of the ventilatory units will close off completely<sup>8</sup>. Low end-expiratory volumes are potentiated during active sleep. In addition, there are lower alveolar pressures during feeding phases (sucking) and when the infant cries (at the immediate beginning of deep and forceful inspiration). This is one reason why some infants may become cyanosed during feeding and crying episodes. The aeromedical staff should provide supplemental oxygen and also facilitate a calm restful environment for the infant. The addition of 5cm  $\text{H}_2\text{O}$  of Positive End-Expiratory Pressure (PEEP) is sufficient to recruit.

Decreased airway diameter

The internal diameter of the airway in infants is proportionally smaller than the adult. During the first two months of life, when most physical parameters in the newborn are increasing rapidly (such as weight and length), the conductance of the airway actually decreases<sup>9</sup>. From the age of two months conductance begins to increase. Any reduction in airway diameter will effect a dramatic decrease in ventilation<sup>10</sup>. This is because resistance to flow is inversely proportional to the fourth power of the radius of the airway (Poiseuille's equation)<sup>13</sup>. Aeromedical staff should be aware that airway compromise in the neonate and infant can occur precipitously due to this physical fact. Aeromedical staff should have appropriate equipment available, such as suction devices to help clear an airway that suddenly becomes occluded.

Fewer alveoli

The respiratory system of the newborn displays significantly different morphology to the adult system. In particular there are proportionally fewer alveoli in the infant<sup>11</sup>. This can predispose to ventilation – perfusion mismatch, and thus hypoxia.

Foetal haemoglobin

Most types of normal haemoglobin, including haemoglobin A, haemoglobin A2, haemoglobin S, and haemoglobin F, are tetramers composed of four protein subunits and four heme prosthetic groups. Whereas adult haemoglobin is composed of two alpha and two beta subunits, foetal haemoglobin is composed of two alpha and two gamma subunits, commonly denoted as  $\alpha_2\gamma_2$ . Because of its presence in foetal haemoglobin, the gamma subunit is commonly called the “foetal” haemoglobin subunit. Foetal haemoglobin (HbF) persists in significant amounts up to three months of age and shifts the oxygen dissociation curve to the left<sup>3</sup>. The effect of foetal haemoglobin on the oxygen dissociation curve will be to enhance loading of oxygen

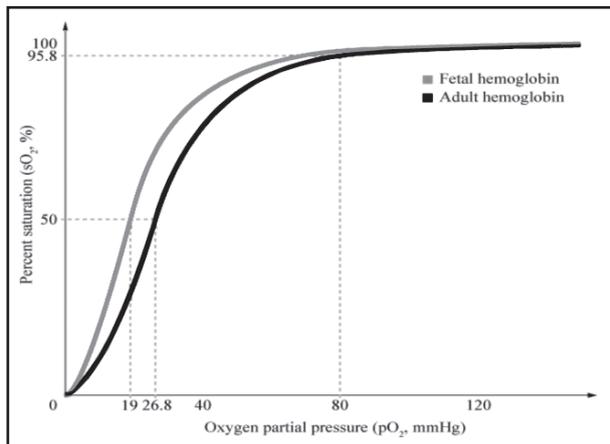


Figure 2: The oxygen saturation curve for foetal haemoglobin (grey) appears shifted to the left when compared to adult haemoglobin (black) since foetal haemoglobin has a higher affinity for oxygen.

Foetal haemoglobin’s affinity for oxygen is substantially greater than that of adult haemoglobin. Notably, the P50 value for foetal haemoglobin (the partial pressure of oxygen at which the protein is 50% saturated - lower values indicate greater affinity) is 19 mmHg, whereas adult haemoglobin has a value of approximately 26.8 mmHg. As a result, the oxygen saturation curve, which plots haemoglobin saturation against  $pO_2$ , is shifted to the left for foetal haemoglobin.

This greater affinity for oxygen is explained by foetal haemoglobin’s interaction with 2,3-diphosphoglycerate (2,3-DPG). In adult red blood cells, this substance decreases the affinity of haemoglobin for oxygen. It is also present in foetal red blood cells, but does not interact with foetal haemoglobin, leaving its affinity for oxygen unchanged. Adult haemoglobin alone actually has a higher affinity for oxygen than its foetal equivalent.

in an hypoxic environment, and possibly to decrease unloading in peripheral tissues<sup>17</sup>.

Barometric pressure changes

The volume of a fixed mass of gas is inversely proportional to the pressure to which it is subjected (Boyle’s law). At the highest cabin altitude usually encountered in aeromedical retrieval flight (8,000 feet), gas will increase in volume by approximately 30 per cent. Gas trapped in a body cavity of a paediatric AME patient will expand at altitude and restrict diaphragmatic motion, compromising respiration and leading to hypoxaemia. Aeromedical staff should consider placing an orogastric or nasogastric tube to decompress the stomach prior to flight.

Hypoxia secondary to congenital pulmonary anomalies and cyanotic heart disease

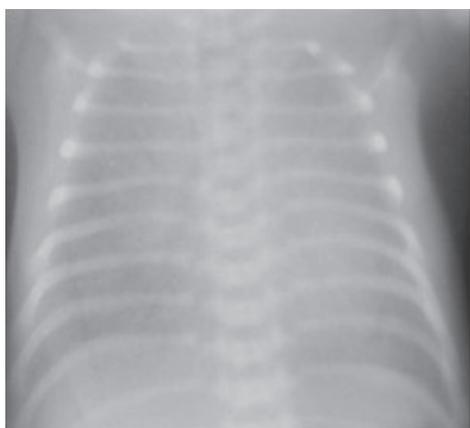
Infants with congenital pulmonary anomalies are at risk for the development of spontaneous pneumothorax during flight<sup>3</sup>. In the paediatric AME patient there may be no obvious symptoms of a developing pneumothorax other than the development of unexplained variations in vital signs and abnormal movements. Paediatric AME staff should thus be vigilant for sudden changes in vital signs, and be aware of the risk of pneumothorax.

Physical phenomena causing hypoxia

The low humidity found in aircraft cabins can increase airway reactivity in some patients. In addition, bronchial secretions may thicken, leading to mucous plugging and atelectasis<sup>3</sup>. The resultant ventilation-perfusion mismatch will lead to hypoxia. Mucous plugging is of special concern in paediatric patients with bronchiectasis and cystic fibrosis.

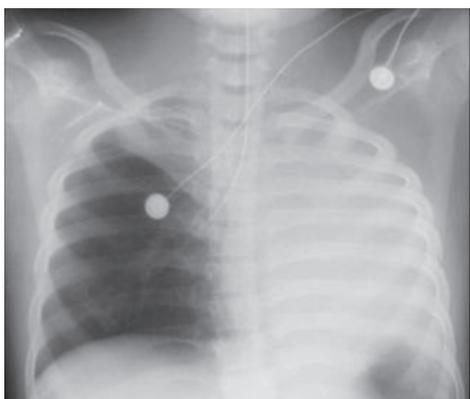


Figure 3: This cyanosed neonate is just two hours old. The infant has been diagnosed with transposition of the great vessels and a ventricular septal defect. Aeromedical transfer of this neonate is a difficult and complex undertaking. The infant may exhibit dramatic episodes of desaturation when exposed to the flight environment<sup>3</sup>.



*Figure 4: The characteristic CXR appearance of respiratory distress syndrome of the newborn, (previously hyaline membrane disease), showing the “ground glass” appearance. Usually due to low lung surfactant levels from prematurity. The alveoli are lined with cellular debris, fibrin, and inflammatory cells. The debris blocks gaseous exchange and renders the infant hypoxaemic. Many of the alveoli are distended and prone to barotrauma. Supplemental oxygen is provided, usually with continuous positive airways pressure (CPAP).*

Helicopters produce more stress from vibration and noise than do fixed wing aircraft. Excess vibration may particularly disturb the sick neonate, producing hypoxaemia, apnoea, or bradycardia<sup>18</sup>. Temperature regulation should be maintained, as hypothermia and shivering increase oxygen consumption, and may aggravate metabolic acidosis and hypoglycaemia in sick infants. As humidity decreases with altitude, additional means to moisten the inspired air should be provided; for example by using nebulised saline. This will help temperature control, fluid balance, and reduce the tenacity of secretions.



*Figure 5: Intubation of the right main bronchus. More severe forms of atelectasis develop when an endotracheal tube occludes one of the main stem bronchi. Significant hypoxaemia will result.*

As infants are obligate nose breathers any obstruction to the nasal passages will cause respiratory distress. The developing trachea is prone to kinking and extension of the neck may lead to airway compromise and subsequent hypoxaemia. The child should be

placed with the shoulders slightly supported. The trachea is also relatively short in the infant and it is easy for the operator to intubate the right main bronchus, with significant complications and hypoventilation<sup>3</sup>.

### Management of the paediatric aeromedical retrieval

#### Background considerations

It is important that the aeromedical staff are aware of the physical, physiological and psychological stressors of flight. In addition to hypoxia, the aeromedical team should also consider other stressors, including the expansion of trapped gasses, noise, vibration and motion. The personnel planning an aeromedical transfer of the paediatric patient should have an holistic approach to the transfer. This approach should consider all aspects of the transfer, including clinical, flight and aeromedical staff. Secondary aeromedical transfer should only occur if it is likely to improve the patient's clinical outcome<sup>19,20</sup>. Further, the transfer should be undertaken in a manner that does not jeopardise the level and quality of care being given.<sup>21,22</sup>

There are published guidelines for the expected standard of care during transportation, with a typical guideline being that provided by the Australian and New Zealand College of Anaesthetists and Australasian College of Emergency Medicine<sup>23</sup>.

#### Paediatric patient assessment & overcoming hypoxia

In paediatric patients who are receiving supplemental oxygen, the fractional inspired oxygen concentration may be increased to account for the hypoxia at altitude. This can be titrated during the journey by continuous pulse oximetry<sup>24</sup>. Another complementary technique is to lower cabin altitudes (maximum cabin pressure of 3700 feet) to ensure haemoglobin  $SO_2$  levels of at least 80%. In infants who are ventilated, it would also be possible to increase the positive end expiratory pressure to help oxygenation. There are a variety of formulae available for predicting hypoxaemia at altitude and these are shown in Fact Box B<sup>3,25,26</sup>.

An alternative method for pre-flight assessment involves hypoxic challenge testing. A convenient method to do this is by titration of the extra oxygen requirement of the infant or young child via whole body plethysmography in a body box, as described in Fact Box C<sup>27</sup>.

#### Communication and documentation

Prior to departure, communication between the originating medical facility and the receiving facility is essential. The aeromedical staff should be very clear as to the nature of their tasking, and in addition, communication between the aeromedical staff is

**Fact box B - Formulae for calculating hypoxaemia in adults at altitude**

1. This relates  $P_{aO_2}$  at altitude (Alt) to  $P_{aO_2}$  at sea level (Ground)<sup>25</sup>.  

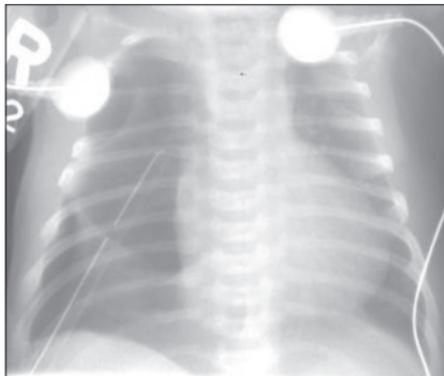
$$PaO_2 \text{ Alt (mmHg)} = 0.410 \times PaO_2 \text{ Ground (mmHg)} + 17.652$$
2. This relates  $P_{aO_2}$  Alt to  $P_{aO_2}$  Ground and includes  $FEV_1$  in litres<sup>25</sup>.  

$$PaO_2 \text{ Alt (mmHg)} = 0.519 \times PaO_2 \text{ Ground (mmHg)} + 11.855 \times FEV_1 \text{ (litres)} - 1.760$$
3. This relates  $P_{aO_2}$  Alt to  $P_{aO_2}$  Ground and includes  $FEV_1$  as % predicted<sup>25</sup>.  

$$PaO_2 \text{ Alt (mmHg)} = 0.453 \times PaO_2 \text{ Ground (mmHg)} + 0.386 \times (FEV_1 \% \text{ pred}) + 2.44$$
4. This relates  $P_{aO_2}$  Alt to  $P_{aO_2}$  Ground and includes flight or destination altitude<sup>3,26</sup>.  

$$PaO_2 \text{ Alt (mmHg)} = 22.8 - [2.74 \times \text{alt. (000's ft)}] + 0.68 \times PaO_2 \text{ Ground (mmHg)}$$

important for crew resource management reasons as it helps to minimise error. Documentation should always accompany the paediatric patient. The documents should be a complete summary of the care to date, and importantly there should also be a summary for rapid reference. Recorded observations should be copied and provided to the receiving medical facility.



**Figure 6:** A right sided pneumothorax in an infant with pulmonary atresia. a chest tube has been inserted; however the lung is only partially inflated. The aeromedical staff must be alert for expansion of trapped gases and sudden deterioration in clinical status.

Selection of aeromedical staff and training

For the aeromedical transfer of paediatric patients, dedicated paediatric retrieval teams have been shown to be safer and more effective than standard aeromedical teams<sup>28,29</sup>. The UK Paediatric Intensive Care Society recommends the use of dedicated paediatric retrieval teams<sup>30</sup>.

Pre-transfer care

Ideally paediatric patients should be physiologically stable prior to transfer<sup>31,32-34</sup>. This requires careful pre-transfer assessment and optimisation of the

**Fact box C - Titration of oxygen requirements at 8,000 ft altitude using whole body plethysmography at ground level**

For oxygen dependent children, including premature infants with chronic lung disease where aeromedical transfer is considered essential, oxygen requirements can be titrated by plethysmography in a body box as follows<sup>27</sup>.

Children are exposed to an hypoxic challenge with an  $FiO_2$  of 15% while sitting on the lap of a carer in a whole body plethysmograph (body box). The infant, receiving oxygen via nasal cannulae, is placed in the body box in the company of a parent or carer, and  $SO_2$  monitored via a probe attached to the child's finger. After measuring  $SO_2$  of the child in air, nitrogen is passed into the body box at approximately 50 l/min\* to dilute the oxygen content of the air to 15% over a period of 5 minutes. Oxygen and carbon dioxide concentrations are measured via continuous flow sampling. The  $SO_2$  can take up to 20 minutes to reach a stable value. Any fall in  $SO_2$  is restored to the original value by titration of the flow of oxygen through the nasal cannulae. This flow of oxygen should then be supplied during the flight.

\*This high rate of flow ensures carbon dioxide does not build up beyond 0.5% within the body box.



**Figure 8:** A whole-body plethysmograph. For infants it is necessary that a parent or carer sits in the box nursing the infant. the healthy parent will tolerate  $SO_2$  of 15% with no difficulty. Photo Joe Mabel-the swedish Hospital Ballard Campus, seattle, Washington. [http://en.wikipedia.org/wiki/File:Body\\_Plethysmography\\_chamber\\_01.jpg](http://en.wikipedia.org/wiki/File:Body_Plethysmography_chamber_01.jpg)

child's status. Lack of anticipation of potential events during the transfer can adversely affect outcome<sup>32,35</sup>. Appropriate aeromedical equipment including monitoring devices, pumps, defibrillators, ventilators and humidicribs should be prepared and checked prior to departure. The aeromedical service should have a system in place so these activities are in a high state of preparedness at all times. Power sources should be examined closely and redundancies calculated for power and oxygen supplies. The parents of the child can be of enormous assistance to the team caring for the paediatric patient. It is important to be inclusive and considerate of their needs at all times. It is also worthwhile for your Desk Officer to ensure that Customs and Quarantine have been informed of the planned mission. Medical and nursing staff should

have appropriate medical indemnity insurance for the location and type of activity they are undertaking<sup>31</sup>.

### During transport

With good preparation and planning there should be little requirement for any active intervention during the flight itself<sup>3</sup>. The patient should be continually reassessed en-route, with the level of monitoring and the frequency of measurement of physiological parameters at least the same or greater than the originating medical facility. The paediatric patient should be monitored with continuous pulse oximetry and ECG. In addition, intermittent non-invasive blood pressure monitoring and temperature at an appropriate interval is indicated. For the ventilated patient a capnographic tracing is recommended. The equipment and therapeutic schedule should be extensive and appropriate for a paediatric patient. The schedule should be stowed in a logical and accessible manner and consumables kept in-date.

### Post-transfer care

The paediatric aeromedical patient remains the responsibility of the transferring team until formal nursing and medical handover has occurred. Ideally this should be at the destination medical facility. The patient should then be reassessed using the ABC method. Monitors and ventilators are then changed to the receiving facility equipment. At this stage it is vital that all connections, lines and tubes are carefully re-evaluated. Documents are then handed over to the receiving medical facility - including blood results and radiographs. It is important to introduce the parents of the paediatric patient to the receiving staff. A post-mission debrief should occur amongst the aeromedical team.

### References

1. American College of Surgeons Committee on Trauma. ATLS 7th Edn. 2004. 243-62
2. Samuels M. The effects of flight and altitude. *Archives of Disease in Childhood* 2004;89:448-455
3. Martin T. Aeromedical transportation: A Clinical Guide. 2nd edition. Ashgate 2006. 193-208
4. Voelkel NF. Mechanisms of hypoxic pulmonary vasoconstriction. *Am Rev Respir Dis* 1986;133:1186-95. [Medline]
5. Teague WG, Pian MS, Heldt GP, et al. An acute reduction in the fraction of inspired oxygen increases airway constriction in infants with chronic lung disease. *Am Rev Respir Dis* 1988;137:861-5. [Medline]
6. Tay-Uyboco JS, Kwiatkowski K, Cates DB, et al. Hypoxic airway constriction in infants of very low birth weight recovering from moderate to severe bronchopulmonary dysplasia. *J Pediatr* 1989;115:456-9. [Medline]
7. Young S, Geelhoed GC, Stick SM, et al. The effect of age on oxygen desaturation during histamine inhalation challenge in normal infants. *Pediatr Pulmonol* 1993;16:158-62. [Medline]
8. Mortola JP, Fisher JT, Smith B, et al. Dynamics of breathing in infants. *J Appl Physiol Respir Environ Exercise Physiol* 1982;52:1209-15.
9. Martinez FD. Sudden infant death syndrome and small airway occlusion: facts and a hypothesis. *Pediatrics* 1991;87:190-8.

### Conclusion

Hypoxia presents one of the greatest challenges when performing aeromedical transfer of the paediatric patient. An appreciation of the anatomical and physiological differences that pre-dispose the infant to hypoxaemia should be requisite knowledge for aeromedical staff. Aeromedical transfer of paediatric patients should be performed whenever possible by dedicated paediatric transfer teams. These teams should have equipment and therapeutic schedules appropriate to the paediatric patient. The aeromedical transfer will be conducted with greater safety and efficiency for patient and staff if crew resource management practices are adopted. This includes, but is not limited to, planning and preparation, communication, briefings, error minimisation and mitigation and thorough equipment checks. Every attempt should be made to ensure the infant being transported is not exposed to any hypoxic interval - especially during those critical stages involving changes of oxygen and ventilators, and emplaning and deplaning.

### Disclaimer

The views, opinions, and/or findings in this report are those of the author and should not be construed as an official policy of the Royal Australian Air Force or the Australian Defence Force.

---

*Author's affiliation: Senior Lecturer Aeromedical Retrieval & Transfer, Department of Aviation and Occupational Medicine, University of Otago*  
*Contact Author: Jeff Stephenson, Squadron Leader (RAAFSR), Director of Medical Services, Senior Medical Officer, 3 Expeditionary Health Squadron, RAAF Richmond, NSW 2755 Australia*  
*Email: jeff.stephenson@otago.ac.nz*

10. Martinez FD, Taussig LM, Morgan WJ. Infants with upper respiratory illnesses have significant reductions in maximal expiratory flow. *Pediatr Pulmonol* 1990;9:91–5.[Medline]
11. Hislop AA, Haworth SG. Airway size and structure in the normal fetal and infant lung and the effect of premature delivery and artificial ventilation. *Am Rev Respir Dis* 1989;140:1717–26.[Medline]
12. Ernsting, Nicholson, Rainford. *Aviation Medicine* 4th edition. Hodder Arnold 2006. 3-12
13. RAAF Institute of Aviation Medicine. *Aviation Medical Officer Course* 2006
14. Poets CF, Samuels MP, Southall DP. Potential role of intrapulmonary shunting in the genesis of hypoxic episodes in infants and young children. *Pediatrics* 1992;90:385–91.
15. Magnusson L, Spahn D. New concepts of atelectasis during general anaesthesia. *British Journal of Anaesthesia*, 2003, Vol. 91, No. 1 61-72.
16. Serafini G, Cornara G, Cavalloro F, et al. Pulmonary atelectasis during paediatric anaesthesia: CT scan evaluation and effect of positive end expiratory pressure (PEEP). *Paediatr Anaesth* 1999; 9: 225–8[Medline]
17. Letsky EA. Anaemia in the newborn. In: Rennie JM, Robertson NRC, eds. *Textbook of neonatology*. 3rd ed. Edinburgh: Churchill Livingstone, 1999: 806–33.
18. Miller C. The physiologic effects of air transport on the neonate. *Neonatal Network–J Neonatal Nursing* 1994;13:7–10.
19. Whiteley S, Gray A, McHugh P, et al. On behalf of the Council of the Intensive Care Society. *Guidelines for the transport of the critically ill adult*. London: Intensive Care Society, 2002
20. The Association of Anaesthetists of Great Britain and Ireland. *Recommendations for standards of monitoring*. London: The Association of Anaesthetists of Great Britain and Ireland, 2000.
21. Pe aloza D, Arias-Stella J, Sime F, et al. The heart and pulmonary circulation in children at high altitudes. *Pediatrics* 1964;34:568–82.
22. Sime F, Banchemo N, Penaloza D, et al. Pulmonary hypertension in children born and living at high altitudes. *Am J Cardiol* 1963;11:143–9.[Medline]
23. Australian and New Zealand College of Anaesthetists and Australasian College for Emergency Medicine. Joint Statement on Minimum Standards for Transport of the Critically ill. 1992 (revised 1996). ANZCA, St Kilda Road Melbourne Vic., Aust.
24. Macnab AJ, Vachon J, Susak LE, et al. In-flight stabilization of oxygen saturation by control of altitude for severe respiratory insufficiency. *Aviat Space Environ Med* 1990;61:829–32.[Medline]
25. Dillard TA, Berg BW, Rajagopal KR, et al. Hypoxaemia during air travel in patients with COPD. *Ann Intern Med* 1989;111:362–7.[Medline]
26. Gong H, Tashkin DP, Lee EY, et al. Hypoxia-altitude simulation test. *Am Rev Respir Dis* 1984;130:980–6. [Medline]
27. Air Travel Working Party: Coker K, Boldy D, et al. British Thoracic Society Standards of Care Committee. Managing passengers with respiratory disease planning air travel: British Thoracic Society recommendations. *Thorax* 2002;57:289-304
28. Edge WE, Kanter R, Weigle GM, et al. Reduction of morbidity in interhospital transport by specialized paediatric staff. *Crit Care Med* 1994;22:1186–91.[Medline]
29. Britto J, Nadel S, Maconochie I, et al. Morbidity and severity of illness during interhospital transfer: impact of a specialised paediatric team. *BMJ* 1995;311:836–9.
30. Paediatric Intensive Care Society. *Standards for paediatric intensive care, including standards of practice for the transport of the critically ill child*. London: PICS, 1996
31. Whiteley S, Gray A, McHugh P, et al. On behalf of the Council of the Intensive Care Society. *Guidelines for the transport of the critically ill adult*. London: Intensive Care Society, 2002
32. Advanced Life Support Group. *Safe transfer and retrieval. The practical approach*. London: BMJ Books, 2002
33. Ridley SA, Wright IH, Rogers PN. Secondary transport of critically ill patients. *Hospital Update* 1990:289–300.
34. Runcie CJ, Reeve W, Reidy J, et al. Secondary transport of the critically ill adult. *Clin Intensive Care* 1991;2:217–25.[Medline]
35. Macartney I, Nightingale P. Transfer of the critically ill. *Br J Anaesth CEPD reviews* 2001;1:12–15.

# Load carriage: minimising soldier injuries through physical conditioning – a narrative review

*LT Robin M Orr<sup>1</sup>, A/Prof Rodney Pope<sup>1,2</sup>, Dr Venerina Johnston<sup>1</sup>, A/Prof Julia Coyle<sup>2</sup>*

## Abstract

**Background:** With soldiers carrying increasing loads, physical conditioning may provide one means of reducing injuries and increasing the ability to train, maintain and retain soldiers.

**Purpose:** The purpose of this study is to review the current literature on physical conditioning for load carriage and present the findings in a manner that will allow physical conditioning practitioners a means of applying them in a conditioning program.

**Methods:** Using key search terms, a literature search of academic databases (both civilian and military) was conducted, with additional relevant literature sought from military and civilian colleagues. Gathered papers were assessed against several key criteria and limited to those relating specifically to physical conditioning and military load carriage. These papers were reviewed to glean key findings in the light of information from additional sources that were employed to contextualise the findings.

**Results:** The search results yielded seven original research papers, one conference paper and four secondary source papers (military reports, journal articles).

**Conclusions:** Research suggests that, while other forms of conditioning may be of a supplemental benefit, an effective load carriage conditioning program will include specific load carriage training conducted between two and four times per month. Loads must be sufficient to elicit a physiological response proportionate to that recommended for cardiovascular and metabolic fitness development, with the duration and distance gradually progressed to levels that meet training and operational needs. While higher intensity training may be of particular value, excessive training volume may increase the risk of both acute and overuse injury risks.

## Introduction

Military personnel are required to carry loads as part of their occupation - loads that, in excess, have altered battle tactics and led to soldier deaths in previous conflicts<sup>1</sup>. With recent evidence suggesting that soldiers are now carrying more load than ever before<sup>2</sup>, there is potential for the injuries and casualties caused by load carriage practices to impact on force generation (the pool of personnel undergoing training and development) and force maintenance (the pool of deployed and deployable personnel).

Acknowledged as placing stress on the musculoskeletal system of the carrier<sup>3</sup>, load carriage tasks have the potential to cause a variety of injuries ranging from blisters, lower back injuries and knee and foot pain<sup>2,4,6</sup>, to stress fractures, and brachial plexus palsy<sup>2,6,7</sup>. With low fitness levels associated with an increase in the risk of injury during general military training<sup>8</sup> and load carriage tasks in particular<sup>2</sup>, physical conditioning to increase fitness levels can provide a

means of limiting load carriage injuries<sup>2</sup>. This concept of conditioning soldiers to carry loads is not new and can be traced back to the Roman Legionnaires<sup>9</sup>. What is lacking however, are practical guidelines on how to condition military personnel for load carriage tasks; a translation of research findings into practice.

The aim of this paper is twofold. Firstly, the paper will review current literature to determine evidence-based best practice for load carriage conditioning. Secondly, the findings will be presented in a format similar to those used by physical educators and trainers to develop physical conditioning programs.

## Methods

### Literature Search: Training for Load Carriage

Research papers and articles that included key search terms related to training and conditioning for load carriage were gathered from numerous sources in two stages. The first stage entailed using databases as an initial starting point and entered key search terms.

These databases and key search terms, which varied slightly depending on the specifics of the databases' search engine, are detailed in Table 1. No language restrictions were applied and, where possible, searches were limited to "human" subjects. In an attempt to identify further research publications of relevance to this literature review, both military and civilian colleagues were contacted.

Database	Search terms
MEDLINE (Ovid)	load AND carr*; load AND march*; pack AND march*; endurance AND march*
PUBMED	load AND carriage; load AND carry; load AND marching; load AND march; pack AND march; pack AND marching; endurance AND march; endurance AND marching.
PROQUEST	load AND carriage; load AND carry; load AND marching; load AND march; pack AND march; pack AND marching; endurance AND march; endurance AND marching.
CINAHL	load AND carriage OR carry; endurance AND march OR marching; pack AND march OR marching; load AND march OR marching.
DEFWEB	load AND carriage; load AND carry; load AND marching; load AND march; pack AND march; pack AND marching; endurance AND march; endurance AND marching.

Table 1: Details of literature search: databases used and search terms.

Once all initial papers were gathered, duplicate studies were removed and abstracts used to review and exclude papers that were clearly unrelated to load carriage by humans (eg. non-human subjects, pathology studies). The papers were then divided into three categories - original research papers, conference papers and secondary source articles (eg journal articles, relevant subject reviews and military reports) with the load carriage research and conference papers subjected to the key exclusion criteria detailed in Table 2.

The second stage of the literature search involved identifying all papers, articles and conference notes which included physical training or conditioning as part of their focus in addition to their load carriage focus. A keyword search for specific terms (program, conditioning, preparation) was also undertaken across all of the first stage documents to ensure that any further relevant literature was identified. Papers not identified through this second stage process were excluded from the review. Finally, as the aim of this paper was to investigate military load carriage, all

Exclusion Criteria	Example:
Participant ages outside typical military service age range of 16 to 65 years	Adolescents
Study included a form of mobility aid	Walking poles
Study included medical supplementation	Ergogenic aids
Study included medically unfit subjects	Idiopathic scoliosis
Study included components in an altered environment	Microgravity, high altitude
Study not published in English	
Study did not include a load carriage variable (dependent or independent); was not specifically related to a load carriage activity; or involved no physical loads being carried	General military conditioning programs
Study had a commercial interest	Commercial backpacks
Defence documents which were rated above "unclassified".	

Table 2: Exclusion criteria applied to the literature search and examples of excluded subjects.

papers (n=2) that did not include loads carried on the back in a load carriage system<sup>10</sup> or focus specifically on load carriage conditioning<sup>11</sup> were removed from the final document set relating to training for load carriage.

#### Literature Review and Contextual Sources

The research reports yielded by the literature search were reviewed using a narrative approach. In order to contextualize these reports within a practical implementation framework, the reports were considered in the light of pertinent information from the broader fields of physical training. On this basis, the literature review synthesized key findings from the identified reports with information gathered from a wide range of published physical training literature. The findings are presented utilizing a funneled approach, whereby general physical training concepts are presented initially, in order to provide the necessary framework for presenting the findings of the load carriage literature review.

#### Search Results

Following the first stage of the literature search, 8,053 papers were identified from the databases search and 36 additional papers were gathered from colleagues and journal article reference lists. The initial exclusion of clearly non-relevant and duplicate articles reduced the number of papers to 291. From these papers, three full text articles could not be obtained through

# Review Articles

Author (date)	Pop	Training Program	Objective Measures and % improvement	Potential confounders / biases	Publisher
Harman et al., (2008)	Civilian ♂ n=32 1) n=15 2) n=17	8 Week program 90 mins x 5 / week 1) Weight based training - Full body weight training, 3.2 km runs, intervals, agility and progressively loaded 8 km march 2) Army Standardized Physical Training - Stretching, callisthenics, movement drills, sprints, shuttle and distance runs	A) 3.2 km run with 32 kg 1) 15% (time) 2) 14% (time) B) 400m run with 18 kg load 1) 16% (time) 2) 11% (time)	Gender Background – Non military	Journal of Strength and Conditioning Research – Peer Reviewed Journal
Knapik et al., (1990)	Soldiers ♂ n=137 (started) 1) n=26 2) n=19 3) n=33 4) n=24	9 Week program 1) March x 0 / month 2) March x 1 / month 3) March x 2 / month 4) March x 4 / month All programs included progressive running, intervals, resistance training and callisthenics	20 km Road march with 46 kg load 1) – 12.9% (time) 2) – 13.9% (time) 3) – 5% (time) 4) – 7.7% (time) While all groups were slower due to longer breaks and weather variations groups 3) and 4) were 11% faster than groups 1) and 2)	Gender Diurnal variances (temperature = ave 16oC warmer) Variances in rest periods during march	US Military Technical Report
Kraemer et al., (2001)	Untrained ♀ n=93 1) n=17 2) n=18 3) n=18 4) n=15 5) n=14 6) n=11	6 Month program 3 sessions / week 1) Total body Resistance – explosive 2) Upper body Resistance – explosive 3) Total body Resistance – traditional 4) Upper body Resistance – traditional 5) Field – plyometrics 6) Aerobic NOTE: All groups included supplemental aerobic exercise NOTE: No load carriage conditioning	A) 3.2 km loaded run with 44.7 kg as fast as possible 1) ± 10% (time) 2) ± 6.5% (time) 3) ± 11% (time) 4) ± 11% (time) 5) ± 11% (time) 6) – 1% (time)*	Gender Age (means 21.1-24.8 years) Untrained Background – non military	Medicine & Science in Sports & Exercise – Peer Reviewed Journal
Kraemer et al., (2004)	Soldiers ♂ n=35	12 Week program 4 sessions/week 1) Resistance + endurance trg 2) Upper body resistance + endurance trg 3) Resistance trg only 4) Endurance trg only NOTE: No load carriage conditioning	A) 3.2 km loaded run with 44.7 kg as fast as possible 1) 14% (time) 2) 10.8% (time) 3) 4.2% (time) 4) 0.5% (time)	Gender Age (means 21.4-24.3 years)	Military Medicine – Peer Reviewed Journal
Patterson et al., (2005)	Soldiers March 1: ♂ n=34 ♀ n=28 March 2: Soldiers ♂ n=18 ♀ n=12	12 Week program 1) Specialised training group - 60 min sessions x 3 / week with circuit training, run sessions and 2 x marching sessions (1 x 25 min; 1 x 30 min) 2) Control group - Standard unit physical training programs (not detailed)	A) 15 km march with a load of 34.6 kg at a target speed of 5.5 km/h 1) N/S (completion rate) 2) N/S (completion rate) B) Run, Dodge and Jump Course 1) N/S (time / completion rate) 2) N/S (time / completion rate)	Diurnal variety between Aug and Nov trials Drop out rates No details provided on unit physical training programs Only two short load carriage sessions in 12 week period Pace was set for the loaded march assessment	Australian Military Technical Report
Rudzki (1989)	Soldiers ♂ n=93 1) n=46 2) n=48	11 Week program 1) Run Group Standard endurance program (Run and march) 2) March group - Loads: 16.2 kg (Weeks 1-3), 18.6 kg (Week 5), 21.2 kg (Week 6), 23.8 kg (Week 7), 26.4 kg (Week 8), 29 kg (Week 9), Field equipment (Week 10); dressed in fatigues with rifle - Speed: 5 km /h up to week 6, then 7.5 km/h for	A) Aerobic fitness on Monark cycle ergometers. 1) 11.97% (VO2) 2) 8.6% (VO2)	Gender Age (means: 1) 19.9 years; 2) 19.6 years) Two different platoons with different staff No balance order therefore subject to individuality of group Drop out rates of 20% per group (although equal between groups)	Military Medicine – Peer Reviewed Journal
Williams et al., (1999)	Soldiers ♂ n=47 ♀ N = 10	10 Weeks of basic training 71 periods of 40 min physical training with prolonged marching and loads on military exercises	A) Loaded march over 3.2 km as fast as able with 15 kg (LM15) or 25 kg ♀ only (LM25) - LM15 3.6% (time) - LM25 15.7% (time) B) Aerobic fitness via 20m shuttle run - 6.1% (VO2 max)*	Age (means: ♂ = 19.4; ♀ = 21.4) Two different platoons with different staff No females in the platoons that had significant finds Learning effect due to presentation order	Ergonomics – Peer Reviewed Journal
Visser et al., (2005)	Soldiers ♂+♀ n=50	8 Weeks 1) Load 20-32% (♀) or 25-40% (♂) BW, 8.3-16.5 km per session, weekly 2) Load 20-32% (♀) or 25-40% (♂) BW, 8.3-16.5 km per session, fortnightly 3) Load 35-55% (♀) or 45-67.5% (♂) BW, 4.1-5.5 km per session, weekly 4) Load 35-55% (♀) or 45-67.5% (♂) BW, 4.1-5.5 km per session, fortnightly	A) Incremental Load March Test – Starting load 15 kg (♀) or 25 kg (♂) increasing up to 62.5 kg in 12.5 kg increments every 1000m. Speed started at 6 km/h, and if participants were able to meet all weight increases, speed was then increased by 0.5 km/h every km 1) 7% (march increments) 2) 6% (march increments) 3) 18% (march increments) 4) 9% (march increments)	Unknown gender distribution Learning effect of incremental load test	Conference paper

Table 3: A tabulated overview of the key papers used.

library, peer or military sources and were therefore also excluded. Judging from the article titles, it is highly unlikely that these papers would have met the inclusion criteria and were therefore deemed non critical papers. Following the implementation of the listed exclusion criteria, the number of articles was further reduced to 215 (124 primary research; 32 conference; 59 secondary source). The second stage of the literature search further reduced the total number of papers to 11 (7 original research; 1 conference; 3 secondary source). A tabulated overview of these original research papers and the conference paper is presented in Table 3. The secondary source articles included a non-experimental military report<sup>6</sup>, a peer reviewed load carriage review<sup>2</sup> and a military journal article<sup>12</sup>.

### Literature Review Results and Discussion

#### The Principle of Specificity

The principle of specificity has as its essence the need to conduct task specific physical conditioning<sup>13,14</sup>, supporting claims that load carriage tasks need to be included in a conditioning program designed to improve load carriage ability<sup>2,10,11</sup>. As an example of the specificity concept, a study by Genaidy et al. (1989)<sup>10</sup> had an experimental group participate in eight training sessions (2.5 weeks) replicating a repetitive lift-and-carry task (20 kg load). Following completion of the program, the experimental group significantly improved their ability to continue the repetitive lift-and-carry task by 50 % more time than the improvement time observed in the control group.

Conversely, a specialized 12-week conditioning program for Australian soldiers, which included circuit and resistance training, running, and load carriage marching, was evaluated by Patterson et al. (2005)<sup>15</sup>. The study found that, while soldiers increased in strength and aerobic capacity following the program, completion time for a 15 km march (35 kg load) and an agility course (10 kg load) did not change significantly. While seasonal temperature variations are expected to have contributed to producing this non-significant finding, limiting the physical conditioning program to only two load carriage sessions throughout the program (Week 3 and Week 5) may have also been a factor in minimizing any observable effect of the training. Furthermore, the duration of the longest conditioning load carriage march (30 minutes) was notably shorter than the duration of the 15 km event (165 minutes). This finding raises the further question of whether there is a minimum training dose (frequency, intensity and volume) required to elicit a training response for load carriage.

Conducting a study to compare the impact of different training doses on load carriage capacity, Visser et al. (1995)<sup>16</sup> compared a high intensity (load) and low volume (distance) training regime to one of a lower intensity (load) and higher volume (distance) (detailed in Table 4). Speed was kept constant at 5.5 km/h. Both training dose combinations were reviewed against the effects of training frequency (number of sessions per week). Their study found that, while all groups improved in strength, aerobic endurance, speed of march and progressive load march performance, the higher intensity (load), lower volume (distance) groups improved to a greater degree in the progressive load march test (detailed in Table 3) than the lower intensity, higher volume groups (See Table 4). Furthermore, the groups training with a higher frequency (once per week) improved to a greater extent than those training with a lower frequency (once per fortnight)<sup>16</sup>. These findings suggest that training improvement is best facilitated by intensity (load), followed by training frequency (sessions per week) and then by volume (distance).

Training dose combinations	1 x / fortnight	1 x / week
<b>High intensity (load), lower volume (distance) groups (35 to 67.5 % bodyweight for 4.1 to 5.5 km / session)</b>	9.1 %	17.9 %
<b>Low intensity (load), higher volume (distance) groups (20 to 40 % bodyweight for 8.3 to 16.5 km / session)</b>	5.7 %	7.3 %

Table 4: Study results comparing training dose to training frequency (% improvement).

Over the longest distance march reported in the selected papers, Knapik et al. (1990)<sup>17</sup> investigated the impact of a nine week conditioning program with the frequency of load carriage sessions ranging from none up to four sessions per month (0, 1, 2, 4 sessions per month with loads from 18 to 34 kg up to a distance of 16 km per session). The study found that the two groups training twice or more per month were 11 % faster over a 20 km distance (46 kg load). The study also found no significant differences between the groups that trained twice versus four times per month.

The differences in findings between Knapik et al. (1990)<sup>17</sup> and Visser et al. (1995)<sup>16</sup> regarding load carriage training frequency may lie in the markedly different training programs, most notably load carriage intensity (load) and load carriage volume (distance). The Knapik et al. (1990)<sup>17</sup> findings may however suggest that a 'law of diminishing returns'<sup>18</sup>

exists, where fitness gains decrease with the amount of exposure (in this case training frequency).

Rudzki (1989)<sup>5</sup> conducted a study comparing two 11-week recruit conditioning programs. One program consisted of endurance running, load carriage, and other conditioning activities (run group), the other replaced all the running sessions with weight load marching (load-marching group). Rudzki (1989)<sup>5</sup> found that, although both groups made similar gains in aerobic fitness, the rate of development was different between each group. The run group made significant improvements in aerobic fitness in the first six weeks of the conditioning program while the load-marching group made gains in the last five weeks. In the latter case, the time period in which significant improvements occurred coincided with an increase in walking speed (from 5 km/h to 7.5 km/h) and an increase in loads carried (16.2-21.2 kg to 23.8-29 kg). While the paper does not specifically detail changes to volume (duration) or frequency (times per week) it is expected that both of these parameters increased as the field training focus increased towards the latter half of the recruit training program. Ultimately, however, these results suggest that, to make significant gains in aerobic fitness and load carriage ability, the load carriage program needs to be at an intensity (load and speed) that is sufficient to stimulate adaptation. These findings, together with those of Visser et al., (1995)<sup>16</sup>, suggest that load carriage intensity (load and speed) is a key factor in improving load carriage performance.

Contrary to the principle of specificity, improvements in load carriage ability may be made without including load carriage training in the conditioning program. In a 12 week (male soldiers)<sup>19</sup> and a 24 week (untrained females)<sup>20</sup> study, Kraemer et al. (2001, 2004) had groups training three (untrained females) to four (male soldiers) times per week following various training protocols which included resistance training (full body or upper body, power orientated or hypertrophy orientated), and aerobic training (long distance running and sprint intervals), either in combination or in isolation. The conditioning programs that employed a combined training approach of both resistance training and aerobic training were associated with significant improvements in 3.2 km run (44.7 kg load) completion time. Interestingly, in both studies, the participants who followed programs employing either resistance training<sup>19</sup> or aerobic training<sup>19,20</sup> in isolation failed to make any significant improvements in loaded run times. The investigators suspect that upper body strength, which in turn improves posture maintenance, lead to an increase in energy efficiency and hence aided in improving load carriage task performance.

### The Impact of Concurrent Training

Concurrent training involves training for more than one physiological response (e.g. strength and aerobic endurance) at the same time<sup>21</sup>. The results of Kramer et al (2001, 2004), noted above, suggest that, contrary to the findings of some research, which questions the value of concurrent training in contexts other than load carriage<sup>21</sup>, a combination of resistance training and aerobic training may be of value for load carriage conditioning. Supporting the use of concurrent training in load carriage training are the research findings of Harman et al (2008)<sup>22</sup>, who compared two physical conditioning programs. The first program followed a new U.S. Army Standardised Physical Training regime (including weight load marching, stretching, calisthenics, sprints, shuttle runs, and medium-distance runs (12-18 mins runs) and the second a weight-based training program with an increased resistance training focus (including weight load marching, full body resistance, longer-distance, ability based, runs (20-30 min runs), sprinting, and agility training). Both groups were found to make similar, significant improvements in short duration load carriage abilities (400 m with 18 kg load and 3.2 km with 32 kg load).

In a study reviewing the British Army Basic Training conditioning program, which consisted of seventy-one 40 minute periods of physical conditioning (sports, circuits, swimming and endurance sessions) as well as prolonged marches with various loads during military exercises, Williams et al. (1999) found that only one of the two platoons made significant improvements in load carriage performance<sup>23</sup>. A male only platoon (N=33) which was assessed completing a 3.2 km distance (25 kg load) as fast as possible significantly improved in time (15.7 %), while an integrated platoon (male n=13; female n=8) failed to make a significant improvement in an assessment conducted over the same distance, in the same manner, with a lighter load (15 kg); even when the results were separated by gender. A potential reason for these differences arises from typical inter-platoon differences (e.g. platoon construct, platoon staff and daily program), making it impossible to draw firm conclusions about the value of concurrent training from these results.

The value of concurrent training is further supported by research findings which have correlated load carriage task ability with neuromuscular ability<sup>24</sup> and aerobic fitness<sup>15,25</sup>. A study by Frykman et al (2000), for example, found that female soldiers who could do more push ups and sit ups had faster obstacle course times (14 kg and 27 kg loads)<sup>24</sup>. Additionally, Lyons et al (2005), noted that as load increased (from 0 kg to 20 kg to 40 kg) and subjects became less efficient, a higher absolute aerobic capacity was essential for

performance during a 60-minute load carriage task (4 km/h at inclines of 0, 3, 6, and 9 %)²⁵.

With studies by Kraemer et al (2001, 2004),<sup>19,20</sup> suggesting that load carriage performance can be improved with concurrent training that excludes specific load carriage training, two factors need to be considered. Firstly, it should be noted that subjects with lower levels of fitness and exercise make greater initial gains regardless of the type of training employed, after which specific training is needed to improve performance for a specific task<sup>11</sup>. Secondly, specific training can impart gains other than those measured by objective means. The aforementioned study by Rudzki (1989)<sup>5</sup> identified that, while both the run group and the load-marching group made similar gains in aerobic fitness, the load-marching group were subjectively rated by staff as performing better at military tasks than the run group.

### The Principle of Recovery

Just as the training frequency, volume and intensity are important factors to consider in the design of a load carriage conditioning program, so too is the concept of recovery. The principle of recovery highlights the need for the systems of the body to have a sufficient recovery from the training stimulus to prevent overload and injury<sup>13</sup>. Failure to provide recovery in the training program and to instead employ high volumes of vigorous weight bearing activities continuously has been identified as a causal factor in high injury rates among military personnel<sup>26</sup>. One means of providing recovery from a progressive training stimulus is to reduce the total volume (distance) of conditioning<sup>13</sup>. This volume reduction strategy has been found to dramatically reduce injury rates during recruit training, without negatively influencing fitness<sup>7</sup>.

With this in mind, it may be suitable to strategically place recovery periods throughout long term load carriage training programs. These 'orthopaedic holidays'<sup>27</sup> should be long enough to ensure that some musculoskeletal recovery takes place, yet short enough to limit detraining, as lengthy breaks in load carriage conditioning have been found to increase the chance of injury when soldiers return to heavy load carriage activities<sup>4</sup>. How long these periods should be is difficult to prescribe, as recovery requirements and detraining rates vary between different anatomical<sup>27</sup> and physiological parameters<sup>14</sup>. Consequently, a structured and progressive conditioning program with built in recovery periods is recommended. Loosely implemented in the Australian<sup>7</sup> and British<sup>27</sup> defence forces, this conditioning structure has been found to decrease the incidence of military trainee injuries.

Finally, a point of caution - while load carriage conditioning may maximise an individual's load

carriage ability, there will still be a finite limit to the carrier's physical ability<sup>12</sup>. Therefore, while a well conditioned individual may be able to carry a heavier load than someone less well conditioned, there will still be a load threshold above which they will be overloaded<sup>28</sup>.

### Practical Implementation

While the above findings suggest that physical conditioning may improve load carriage task performance, to be of a practical value, the load carriage research needs to be presented and applied in a manner consistent with the programming approach used for traditional physical conditioning. One such approach is the F.I.T.T. (frequency [how often], intensity [how hard], time [how long] and type of training) principle or a derivative thereof<sup>14</sup>. In this section, we attempt to present the key information for load carriage conditioning using this approach.

#### Frequency

As a result of their findings, Knapik et al. (1993, 2004)<sup>2,29</sup> recommended that weight load marching be conducted at least two times a month with loads that soldiers are expected to carry in a unit on operations. Visser et al. (1995)<sup>16</sup> however found greatest improvements with sessions conducted weekly versus fortnightly. Considering both of these findings, the 10-day load carriage conditioning cycle implemented in the Netherlands<sup>6</sup> may in fact be the optimal frequency in the training dose. This frequency may however vary depending on training intensity (load, speed) and training volume (time or distance).

#### Intensity

To stimulate aerobic fitness adaptations, the load carriage conditioning intensity (eg. load, speed) needs to be sufficient enough to elicit a training response. While research has suggested higher intensity training to be of particular benefit for improving load carriage performance<sup>5,16</sup>, the potential for injury following a long period of high intensity load carriage<sup>2</sup> must be considered. Ultimately, the conditioning program needs to ensure that personnel are being conditioned to carry loads at the intensities required for military exercises and operational tasks, whilst being cognisant of the fact that, no matter how much conditioning is undertaken, there is still a point beyond which the load carriage task will become too much for the carrier to physiologically withstand<sup>12</sup>.

#### Time

The conditioning stimulus time (or distance) must be considered against both the intensity of the task and the outcome requirements. Just as short duration, high intensity sessions can be used to develop the

ability to move rapidly for short durations (under direct fire for example)<sup>14,30</sup>, longer duration sessions are needed to develop the physical and mental stamina to endure long duration tasks (dismounted patrols, for example)<sup>30</sup>.

### Type of Training

The principle of specificity identifies the need for the conditioning context to meet the requirements of the performance context. However, the concept of concurrent training also suggests that other forms of physical conditioning may be useful to supplement the conditioning program, especially for the less fit. The results of the reviewed research suggest that exercises which stimulate upper body strength and increase aerobic fitness, in particular, may be of benefit for load carriage, provided they do not become the focal point of the training and reduce time allocated to load carriage specific training.

Finally, the principle of recovery demands that the overall load carriage conditioning program be structured and progressive, and include musculoskeletal recovery periods to help mitigate overuse injuries. Each of these concepts is supported by the review of pertinent research results, presented above.

### Implementation Guide

In summary the author's recommend that military physical conditioning programs include:

- two to four evenly spaced load carriage sessions per month;
- carried loads that are initially light yet progress in weight to meet that required for given military tasks;
- load carriage task durations and distances that gradually increase (yet not at the same time as increase in load) to meet military requirements;
- periods of recovery spaced throughout the program to allow the body to recover from the conditioning stimulus; and
- supplemental conditioning (muscle strength and aerobic training) sessions utilising functional movement patterns to provide adaptation to a broad spectrum of load carriage duties and tasks.

### References

1. Marshall SLA. *The Soldier's Load and the Mobility of a Nation*. Virginia: The Marine Corps Association; 1980.
2. Knapik JJ, Reynolds KL, Harman E. Soldier load carriage: Historical, physiological, biomechanical, and medical aspects. *Mil Med*. 2004;169(1):45-56.
3. Harman E, Han K-H, Frykman PN. Load-speed interaction effects on the biomechanics of backpack load carriage. RTO Meeting Proceedings 56: Soldier Mobility: Innovations in Load Carriage System Design and Evaluation. Kingston, Canada: Research and Technology Organisation/North Atlantic Treaty Organization; 2000.

### Limitations of this review

Several limitations to the establishment of evidence of best practice and the subsequent guidelines issued in this paper are acknowledged. The heterogeneity of the populations in the identified research is high. While differences in motivation and experience can be found when comparing military and civilian participants, so too can differences be found across defence groups (comparing recruits in training and fully qualified soldiers, for example). Due to the limited number of core research papers focused on load carriage conditioning, the data could not be limited to only one such group and so all researched groups that undertook load carriage utilising systems akin to those in the military were included. Another limitation lies in the possibility that not all relevant papers may have been identified during the literature search. Likewise, military research papers that were rated above 'unclassified' could not be used in this public-domain review, due to security restrictions. Potentially limiting the application of the findings of this paper is its specificity. With the focus being on military load carriage, the generalisability of the results to other occupations which include load carriage will be limited primarily to those required to carry heavy loads on their backs, including fire fighters wearing breathing apparatus, special operations police and trail porters. The conditioning guidelines may, however, also be of use for recreational activities like distance hiking and mountaineering, where heavy loads are carried on the back.

### Recommendations for future work

While this paper is able to provide some basic guidelines for physical conditioning for load carriage, specific intervention studies manipulating load carriage training doses in conjunction with established military physical conditioning regimes would be valuable to further progress information in this field.

---

*Authors' affiliations: <sup>1</sup>University of Qld <sup>2</sup>Charles Sturt University.  
Corresponding author: LT Robin M Orr, The Physical Conditioning Optimisation Review (PCOR) Project,  
The Royal Military College-Duntroon, DUNTRON,  
Australian Capital Territory, 2601, Australia.  
Email: Robin.Orr@defence.gov.au*

4. Knapik JJ, Reynolds KL, Staab J, et al. Injuries associated with strenuous road marching. *Mil Med.* 1992;157(2):64-67.
5. Rudzki SJ. Weight-load marching as a method of conditioning Australian Army recruits. *Mil Med.* 1989;154(4):201-205.
6. van Dijk J. Chapter 3 - Common Military Task: Marching. *Optimizing Operational Physical Fitness.* RTO-TR-HFM-080. NATO Research and Technology Organisation. 2009.
7. Pope R. Prevention of pelvic stress fractures in female army recruits. *Mil Med.* 1999;164(5):370-373.
8. Pope R. Prediction and prevention of lower limb injuries and attrition in army recruits, Charles Sturt University; 2002.
9. Rhenanus FV. *Vegetius: Epitome of Military Science.* 2nd ed. Liverpool: Liverpool University Press; 1996.
10. Genaidy AM, Mital A, Bafna KM. An endurance training program for frequent manual carrying tasks. *Ergonomics.* 1989;32(2):149-155.
11. Williams AG, Rayson MP, Jones DA. Training diagnosis for a load carriage task. *J Strength Cond Res.* 2004;18(1):30-34.
12. Porter SC. The Soldier's Load. *Infantry.* 1992;May-June:19-22.
13. Pyke FS. Principles of Training. In: Pyke FS, ed. *Better Coaching: Advanced Coach's Manual.* 2nd ed. Canberra: Human Kinetics; 2001:101-110.
14. Wilmore JH, Costill DL, Kenney L. *Physiology of sport and exercise* 4th ed. Champaign, IL: Human Kinetics; 2008.
15. Patterson MJ, Roberts WS, Lau WM, et al. Gender and Physical Training Effects on Soldier Physical Competencies and Physiological Strain. *Defence Science and Technology Organisation.* 2005:65.
16. Visser T, van Dijk MJ, Collee T, et al. Is intensity of duration the key factor in march training? Paper presented at: International Congress on Soldier's Performance. Finland. 2005.
17. Knapik JJ, Bahrke M, Staab J, et al. Frequency of Loaded Road March Training and Performance on a Loaded Road March. T13-90. Military Performance Division. US Army Research Institute of Environmental Medicine, Natick. 1990:52.
18. Zernicke RF, Wohl GR, LaMothe JM. The Skeletal-Articular System. In: Tipton CM, American College of Sports Medicine, Sawka MN, et al., eds. *ACSM's Advanced Exercise Physiology.* Lippincott, Williams & Wilkins; 2005:41-94.
19. Kraemer W, Vescovi JD, Volek JS, et al. Effects of concurrent resistance and aerobic training on load-bearing performance and the army physical fitness test. *Mil Med.* 2004;169(12):994-999.
20. Kraemer W, Mazzetti S, Nindl BC, et al. Effect of resistance training on women's strength/power and occupational performances. *Med Sci Sport Exer.* 2001;33:1011-1025.
21. Leveritt M, Abernethy PJ, Barry BK, et al. Concurrent Strength and Endurance Training: A Review. *Sports Med.* 1999;28(6):413-427.
22. Harman E, Gutekunst DJ, Frykman PN, et al. Effects of two different eight-week training programs on military physical performance. *J Strength Cond Res.* 2008;22(2):524-534.
23. Williams AG, Rayson MP, Jones DA. Effects of basic training on material handling ability and physical fitness of British Army recruits. *Ergonomics.* 1999;42(8):1114-1124.
24. Frykman PN, Harman E, Pandorf CE. Correlates of obstacle course performance among female soldiers carrying two different loads. *RTO Meeting Proceedings 56: Soldier Mobility: Innovations in Load Carriage System Design and Evaluation.* Kingston, Canada: Research and Technology Organisation/North Atlantic Treaty Organization; 2000.
25. Lyons J, Allsopp A, Bilzon J. Influences of body composition upon the relative metabolic and cardiovascular demands of load-carriage. *Occup Med (Lond).* 2005;55(5):380-384.
26. Pope R. Programming in Military Physical Training: Gender, age & fitness considerations. *Army Fitness Training Programs Workshop.* Canberra: Defence Health Services Branch; 2001.
27. Ross RA. Stress fractures in Royal Marine recruits. *Mil Med.* 2002;167(7):560-565.
28. O'Connor JS, Bahrke M. The Soldier's Load: Planning Smart. *Infantry.* 1990;Jan-Feb:8-11.
29. Knapik JJ, Johnson RF, Ang P, et al. Road March Performance of Special Operations Soldiers Carrying Various Loads and Load Distributions. T14-93. Military Performance Division. US Army Research Institute of Environmental Medicine, Natick. 1993:136.
30. Bompa TO, Haff GG. *Periodization: Theory and Methodology of Training,* 5th ed: Human Kinetics; 2009.

# The development of dengue vaccines and their military significance

*S J Kitchener*

*Reprinted from Australian Military Medicine Volume 9(2): 71-73.*

## Background of dengue in the South West Pacific Region

Dengue has become a world-wide disease with more than 100 million cases per year.<sup>1</sup> It is the leading cause of arboviral infection in humans.<sup>2</sup> The current global pandemic of dengue arose from the combination of ecological disruption and demographic changes associated with World War II in Asia and the Pacific.<sup>3</sup> A major regional pandemic occurred around Australia in the final years of the war. With the isolation of the Pacific islands, dengue disappeared until outbreaks of dengue 3 in Tahiti in 1964 and dengue 2 in Fiji in 1971. Dengue 2 subsequently spread to island groups east and west of Fiji. Dengue 1 reintroduced to the area in 1975 and dengue 4 in 1979.

Multiple epidemics of dengue occurred in north Queensland in the late 19th century with the first clinical descriptions of dengue haemorrhagic fever during an epidemic in 1897.<sup>4</sup> Following a subsidence of dengue in Australia after World War II, dengue 1 reappeared in 1981 in north Queensland and continued transmission until 1990.<sup>5</sup>

## Contemporary military significance

The military significance of dengue is multifaceted including loss of manpower through non-battle casualties, loading of the logistic chain with casualties, importation of dengue to Australia during re-deployment and the subsequent deployability of those contracting dengue.

The vector for dengue viruses, *Aedes* mosquitoes, typically breeds in artificial containers. Suitable breeding sites are the debris remaining from the destruction of urban environments as well as wells, tanks and other storage containers left unmanaged when civil infrastructure breaks down. Under these circumstances, dengue will accompany peace keeping and peace making forces. The INTERFET experienced a significant number of non-battle casualties arising from dengue.<sup>6</sup> The United States peace keeping and peace making forces in Haiti and Somalia also experienced large numbers of dengue cases among deployed personnel serving in similar areas of urban devastation arising from conflict.<sup>7,8</sup>

The operational significance of dengue lies in the nature of the clinical condition. Typically, dengue develops within one to two weeks of transmission from an *Aedes* mosquito. Common symptoms are fever, macular rash, headache, retro-orbital pain, arthralgia and myalgia, which may last a further one to two weeks or longer with a fatigue syndrome.<sup>9</sup> Most non-immune adults infected will develop the clinical syndrome to some extent.<sup>10</sup> Such debilitation of personnel in this space of time reduce both manpower and manoeuvrability by depletion of the effective fighting force and loading the health service support elements.

With the control of local transmission of dengue in Australia, the possibility of importing dengue into receptive areas of the country by returning soldiers must be of significance to military planners. Importation of dengue from the areas to the immediate north have caused major outbreaks of dengue in north Queensland.<sup>11</sup> The ADF presently has contingents in several dengue endemic areas immediately north of Australia.

Military significance also arises from the increasing single serotype dengue seroprevalence among the deployable force. Dengue haemorrhagic fever has long been attributed to arising from secondary dengue infections.<sup>12</sup> The implications for subsequently deploying seropositive personnel to dengue endemic areas, particularly those areas with a different prevalent serotype to that which immunity has been developed is the possibility of antibody dependent enhanced (ADE) second infections and increased risk of DHF.<sup>13</sup> The risk is probably small, though real.

## Vaccine development

Developing a dengue vaccine is important as only symptomatic and supportive treatment are available for the disease and prevention of transmission is the only management for an outbreak. Dengue vaccines were first generated soon after virus isolation towards the end of World War II. The real challenge of dengue vaccination is to develop a tetravalent vaccine capable of providing protection against all four serotypes to prevent sequential serotype ADE infection.

The Walter Reed Army Institute of Research (WRAIR) began attenuating dengue virus in 1971, producing

a dengue 2 candidate vaccine, which underwent phase 1 trials causing mild illness in some vaccinees. Seroconversion occurred in most (61%) flavi-naïve recipients and 90% of those previously vaccinated with yellow fever vaccine.<sup>14</sup>

Upon support from the Regional Advisory Committee for Medical Research of the South East Asian Regional Office of the WHO, efforts were focused into a single laboratory and the concept of a tetravalent vaccine was agreed upon. The Dengue Vaccine Development Laboratory was established at the Department of Pathology, Ramathibodi Hospital, Faculty of Medicine, Mahidol University. With other Governments, Organisations and Institutions, the Australian Government contributes to this endeavour.

Monovalent vaccine phase 1 trials were begun in mountain communities (free of *Aedes*) in Thailand with flavi-naïve individuals. These vaccines were found to be safe. Subsequently, bivalent vaccines and trivalent vaccines were produced by mixing monovalent vaccines prior to subcutaneous injection. These were found to be safe and immunogenic.<sup>15,16</sup> A tetravalent vaccine was produced with concentrations of each element determined by the 50% minimal infectious dose calculated from monovalent vaccine titrations. In a small phase 1 trial, this formulation was found to be immunogenic. Subsequently, a larger phase 1 trial in children found after one vaccination, one percent of recipients experiencing fever and rash. A second vaccination was administered to 22 of these children six months later. Twenty of the children developed neutralising antibodies to all four dengue serotypes.<sup>17</sup>

A collaboration was established with Pasteur Merieux, now Aventis Pasteur, for further development of the vaccine. A phase 2 trial has attempted to establish most likely candidate formulations in terms of safety and immunogenicity. A proposal for phase 2 trial of two candidate tetravalent dengue vaccine formulations has been provisionally approved to be conducted by the AMI in the ADF in collaboration with Aventis Pasteur.<sup>18</sup> This trial will begin later this year with the first of two vaccinations over a six month period.

### Conclusion

Ultimately, the target population of a tetravalent dengue vaccine will be the children of dengue endemic countries for whom infection is likely and complications are a high risk and carry a high mortality rate. The benefit for the ADF and the military of other nations not endemic for dengue is the possibility of preventing a major cause of non-battle casualties. Initial results of this trial in the ADF will be presented at the 10th Conference of the Australian Military Medicine Association.

---

*Contact author: Assoc Prof Scott Kitchener,  
Centre of Military and Veterans' Health, University  
of Qld, Herston Road, Herston, Qld 4006  
Email: kitcheners@bigpond.com*

### References

1. Monath T. Dengue: the risk to developed and developing countries. *Proc Nat Acad Sci* 1994; 91:2395-2400.
2. Halstead SB. Dengue, yellow fever and rabies. *Curr Opinion Infect Dis* 1994; 7:559-563.
3. Gubler DJ. Dengue and dengue haemorrhagic fever: its history and resurgence as a global public health problem. In Gubler DJ, Kuno G. eds. *Dengue and Dengue Haemorrhagic Fever*. New York: CABI; 1997.
4. Hare FE. The 1897 epidemic of dengue in North Queensland. *The Australasian Medical Gazette*. 17:98-107.
5. Phillips D, Aaskov J. A recent outbreak of dengue fever in north Queensland. *Comm Dis Intel* 1990;22:12-13.
6. WHO Bulletin, Dili Office; 1999.
7. Defraites RF, Smoak BL, Trofa AF, Hoke CH, et al. Dengue fever among US military personnel – Haiti, September-November, 1994. *MMWR* 1994; 43: 845-848.
8. Kanesa-Thesan N, Iaconno-Commers L, Magill A, Smoak B, Vaughn D, Dubois D, Burrous J, Hoke CH. Dengue serotypes 2 and 3 in US forces in Somalia. *Lancet* 1994; 343:678.
9. Lum LCS, George R. Clinical spectrum of infection. In Gubler DJ, Kuno G. eds. *Dengue and Dengue Haemorrhagic Fever*, New York: CABI, 1997..
10. Sabin AB. Research on Dengue during World War II. *Am J Trop Med Hyg* 1952; 1: 30-50.
11. Ritchie S, Hanna J, van den Hurk A, et al. Importation and subsequent local transmission of dengue 2 in Cairns. *Comm Dis Intel* 1995; 19: 366-70.
12. Russell PK, Yuill TM, Nisalak A, et al. An insular outbreak of dengue haemorrhagic fever. II Virological and serologic studies. *Am J Trop Med Hyg* 1968;17: 600-8.
13. Morens DM. Antibody dependent enhancement of infection and the pathogenesis of viral disease. *Clin Infect Dis* 1994; 19:500-12.
14. Bancroft WH, Scott RM, Eckeils KH et al. Dengue virus type 2 vaccine: reactogenicity and immunogenicity in soldiers. *J Infect Dis* 1984;149:1005-10.
15. Bhamarapavati N, Yoksan S. Study of bivalent dengue vaccine in volunteers. *Lancet* 1989;1: 1077.
16. Bhamarapavati N, Yoksan S. Immunisation in humans with live attenuated trivalent dengue vaccine. *S E Asia J Trop Med Pub Hlth* 1993; 24(Suppl 1): 246-49.
17. Bhamarapavati N, Yoksan S. Live attenuated tetravalent dengue vaccine. In Gubler DJ, Kuno G. eds. *Dengue and Dengue Haemorrhagic Fever*, New York: CABI; 1997.
18. AMI. *ADMEC proposal 213/00* 2000 Jun.

# Dengue fever update

*Assoc Prof S J Kitchener*

## Dengue Global Epidemiology

Dengue continues to be a global disease, more so than prior to 2000. In the Americas, cases have become more numerous, particularly Dengue 3 infections, with the highest incidence and mortality among adolescents and children<sup>1</sup>. Since beginning operations in 1999, the European Network on Imported Infectious Disease Surveillance (TropNetEurop) has detected an increasing incidence of dengue imported to Europe, mostly from South East Asia (43%)<sup>2</sup>.

Now 10 years after the publication of "The development of Dengue vaccines and their military significance"<sup>3</sup> outbreaks in Asia and the Middle East are occurring in Saudi Arabia, Yemen, Brunei, Thailand, and Indonesia<sup>4</sup>. In Australia this year, outbreaks have been declared in Tully (February 2010) and Townsville (April 2010), both of which have been Dengue 2 infections<sup>5</sup>.

Despite a number of episodes transiently reducing international travel, the increase in global dengue is related to increased mobility of populations. Dengue is not only emerging with a greater global footprint, but diversifying that footprint in any location with multiple serotypes, thus increasing the risk of complicated dengue infections.

## Dengue in the ADF

Since the publication in 2006 the relevance of dengue vaccines to operations of the Australian Defence Force remains high. The ADF experienced a significant exposure to dengue during deployments to East Timor with initial outbreaks in the forward area of operations and in Dili of at least 160 cases at the Army Malaria Institute<sup>6</sup>. This outbreak included cases of all four serotypes, though mostly Dengue 3. Many lessons of field prevention and management of dengue were relearned and new field diagnostic tests and expertise were developed that proved useful in the following years of continued operations in East Timor and subsequently in other near- north operational areas.

The broader military significance of dengue to the ADF was highlighted by the potential importation of dengue to the receptive area of continental Australia in returning military personnel from operations<sup>7</sup>. The ADF demonstrated superlative preventive medicine expertise in the containment of dengue among

soldiers returning to Townsville from East Timor. At least nine viraemic cases were returned to Townsville and treated at Lavarack Barracks without any local transmission of the virus.

## Progress towards a Dengue Vaccine

The conventional wisdom is that a tetravalent vaccine will be necessary to avoid heterotypic reactions to serotypes against which only marginal immunity is held<sup>8</sup>.

Following the outbreak of dengue among ADF personnel in East Timor, the Defence Health Services became involved in the global effort to develop a dengue vaccine. At that time, Aventis Pasteur in collaboration with Mahidol University in Thailand had gathered strains of dengue from South East Asia to attenuate for tetravalent vaccine candidates. A Phase 1b study was conducted at 2HSB to evaluate the immunogenicity and safety of two dengue vaccine candidates<sup>9</sup>. This study well demonstrated the necessary level of attenuation to maintain immunogenicity whilst ensuring safety.

These candidate vaccines and other live attenuated tetravalent dengue vaccine programs have largely been suspended in favour of more sophisticated approaches. These strains have subsequently been used to develop chimaeric vaccines with yellow fever vaccine. Chimaeric dengue vaccines have been developed combining the DNA coding for the envelope antigens of the dengue serotype with the 17D yellow fever vaccine to produce a replicating viral particle manifesting the dengue serotype envelope antigens with the core of the YF vaccine.

In this format, ChimeriVax-DEN2 has been demonstrated to produce neutralizing antibodies to all four dengue serotypes in association with yellow fever vaccine pre-immunity<sup>10</sup>. Whether this translates into clinically protective immunity is not clear. The development of a tetravalent chimaeric vaccine has progressed to be the leading candidate in dengue vaccines having completed Phase 2b trials in adults<sup>11</sup>. Phase 3 trials of the chimaeric tetravalent vaccine are underway in South East Asia by Sanofi Pasteur and are due for first results in 2012<sup>12</sup>.

This is the leading vaccine candidate program for a tetravalent dengue vaccine. Aventis Pasteur aim for it to be on the market in 2015. Other programs

continue towards further development of tetravalent vaccines. Hawaii Biotech are in Phase 1 trials of a monovalent Dengue-1 vaccine consisting of envelope proteins expressed by an insect cell system. With successful results, this vaccine will next progress to tetravalent trials.

Another chimaeric dengue vaccine has been developed by CDC on an attenuated Dengue-2 backbone used in the same way as Acambis/Sanofi vaccines have used the 17D Yellow Fever vaccine backbone. The CDC vaccine has been licenced to Inviragen for clinical trials towards a tetravalent vaccine due to begin shortly<sup>13</sup>. The clinical trial program is becoming typical of dengue vaccine development with initial trials in dengue-free countries, in this case USA, before Inviragen moves to Singapore for later phase clinical trials in an endemic area. The other feature

of this dengue vaccine development program and the vaccines discussed here is the partnership with significant biotech companies able to scale vaccine development to the levels that will be necessary to supply the world with dengue vaccines when they do become available.

Australia remains on the list of countries in which dengue vaccines are likely to be licensed early due to the quality of research and regulation, the presence of endemic dengue and the proximity to hyperendemic countries.

---

*Authors affiliation: University of Queensland  
Contact author: Assoc Prof Scott Kitchener, Centre  
for Military and Veterans Health, University of  
Queensland, Herston Road, Herston, Qld 4006  
Email: kitcheners@bigpond.com*

### References

1. San Martin JL, Brathwaite O, Zambrano B, Solorzano JO, Bouckenoghe A, Dayan GH, Guzman MG. The epidemiology of dengue in the Americas over the last three decades: A worrisome reality. *Am J Trop Med Hyg* 2010; 82(1): 128-135.
2. Jelinek T. Trends in the epidemiology of dengue fever and their relevance for importation to Europe. *Euro Surveill* 2009; 14(25): pii=19250. Available at [www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19250](http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19250), last checked 22 May 2010.
3. Kitchener SJ. The development of dengue vaccines and their military significance. *Aust Mil Med* 2000; 9(2): 71-73.
4. Dengue/DHF update 2010, Promed Archive 20100510, 10 may 2010.
5. Queensland Health Outbreak Update, Dengue Fever, [www.health.qld.gov.au/dengue/outbreak\\_update/current.asp](http://www.health.qld.gov.au/dengue/outbreak_update/current.asp), 22 May 2010.
6. Kitchener SJ, Reid M, Baade L, Taylor C. Serological testing, clinical incidence and serosurveillance of dengue in the Australian Defence Force, East Timor. *Arbo Res Aust* 2000; 8: 203-207.
7. Kitchener S, Leggat, PA, Brennan L, McCall B. Importation of dengue by soldiers returning from East Timor to north Queensland, Australia. *J Trav Med* 2002; 9: 180-183.
8. Halstead SB. Pathogenesis of dengue: challenges to molecular biology. *Science* 1988; 239: 476-481.
9. Kitchener S, Nissen M, Nasveld P, Forrat R, Yoksan S, Lang J, Saluzzo JF. Immunogenicity and safety of two live-attenuated tetravalent dengue vaccine formulations in healthy Australian adults. *Vaccine* 2006; 24(9): 1238-1241.
10. Guirakhoo F, Kitchener S, Morrison D, et al. Live attenuated chimeric yellow fever dengue type 2 (ChimerVax-DEN2) vaccine: phase I clinical trial for safety and immunogenicity in induction of cross neutralizing antibody responses to all 4 dengue serotypes. *Hum Vaccin* 2006; 2: 60-67.
11. Guy B, Nougarede N, Begue S, et al. Cell mediated immunity induced by chimeric tetravalent dengue vaccine in naive or flavivirus-primed subjects. *Vaccine* 2008; 26: 5712-5721.
12. Senior K. Dengue vaccine efficacy trials in progress. *Lancet Inf Dis* 2009; 9: 662-663.
13. <http://www.inviragen.com/dengue.php>

# Are we ready? Public health since 9/11

David Rosner and Gerald Markowitz

1st edn, xvi + 193 pp, with illustrations, paperback, RRP-USD18.95, ISBN13: 978-0-520-25038-3, Berkeley, University of California Press, 2006.

Following the terrorist attacks of 9/11 in 2001 and the possibility of bioterrorism following the anthrax episode a month later, the engagement of public health in the global counteroffensive against terrorism was probably for the first time in many decades central to the response in the threats facing the United States of America (US). While there have been many books published about 9/11 and terrorism, few have focused on the public health response to these crises and how public health has evolved since then. The first edition of *Are we ready? Public health since 9/11* responds to this need and is based on oral histories and documentation of public health workers. The book contains a Foreword by Daniel M Fox and Samuel L Milbank, Preface, Acknowledgments, a table of Contents, an Introduction, 3 Chapters, a Conclusion, Notes and a comprehensive Index.

*Are we ready? Public health since 9/11* is presented as a 15 x 23 x 1.2 cm paperback publication, which could easily fit in the briefcase or carry bag and is an ideal read for airline lounges as well as in-flight. The full colour front cover depicts a man walking through the rubble after the collapse of the first World Trade Center tower on 11 September 2001. The back cover gives brief details of the book and of the authors. The stated primary target audience is probably all policy makers and implementers, as well as public health personnel. However, the book will appeal to all those involved in responding to terrorism and bioterrorism, including military policy makers and health professionals, as well as students and academic staff involved with counterterrorism and bioterrorism response programs.

The structure of *Are we ready? Public health since 9/11* is fairly straight forward. There is an "Introduction: Remembering the Moment"; three chapters including "September 11 and the Shifting Priorities of Public and Population Health in New York City"; "Emergency Preparedness, Bioterrorism and the States" and "Emergency Preparedness, Bioterrorism, and the CDC: Federal Involvement before and after 9/11"; and a "Conclusion: What Lessons Have We Learned". The book provides insight into the events surrounding 11 September 2001 and the subsequent anthrax attacks and presents a greater understanding of the events,

the complexities, the challenges, and the responses beyond what has been presented in the media and by the small number of public health publications on the events. It discusses the State and Federal agencies involved in the response from the local health department through to the world-famous US Centers for Disease Control and Prevention (CDC). It describes a number of issues that still need to be addressed including the need to strengthen communication, mental health services, interagency cooperation and a various other systems to help deal with known and unknown threats.<sup>2</sup> One of the limitations that is implied by its US centric focus is that it is not international in scope; however the events of 11 September 2001 and afterwards have driven major reforms in public health internationally, particularly with improved surveillance and monitoring programs and public health infrastructure, as well as funding for improved laboratory, research and other strategic networks. The other limitation, pointed out by another recent review,<sup>2</sup> given its focus, is that it does not cover Hurricane Katrina; however the authors admit that the manuscript was complete before this natural disaster unfolded, which was a further transformative event for public health.

The authors are two well known Professors. David Rosner is Professor of Public Health and History at Columbia University and Co-Director of the Centre for the History and Ethics of Public Health at Columbia's prestigious Mailman School of Public Health. Gerald Markowitz is Distinguished Professor of History at John Jay College and the Graduate Centre of the City University of New York. They are also co-authors of *Deceit and Denial: The Deadly Politics of Industrial Pollution*, also from the same publisher as *Are we ready? Public health since 9/11*.

The production of the *Are we ready? Public health since 9/11* is an outstanding effort, even though it does not provide a simple answer to the question "Are we ready?", as suggested by another review.<sup>2</sup> The book has limited competition in the field of public health, although one may occasionally reach for a much larger and much more expensive reference textbook on public health and disasters, such as about to be released *Disasters and Public Health: Planning and Response*,<sup>3</sup>

## Book Reviews

---

to gain deeper insight into a particular condition. The book is a must read for those interested in the public health response to terrorism and bioterrorism and it is relatively inexpensive, especially now that it has started to appear in discount bins.

---

*Reviewed by: Peter A. Leggat, MD, PhD, DrPH, FAFPHM, FACTM, FACRRM, FFTM ACTM, FFTM RCPSG, Professor and Head, School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Townsville, Queensland, 4811, Australia. Email: peter.leggat@jcu.edu.au*

### References

1. Barnett D. Book Review: Are we ready? Public Health since 9/11. By Rosner D, Markowitz G. *British Medical Journal*. 2006; 333: 1225.
2. Koh HK. Book Review: Are we ready? Public Health since 9/11. By Rosner D, Markowitz G. *Journal of the American Medical Association*. 2007; 298: 570-571.
3. Clements B. *Disasters and Public Health: Planning and Response*. London: Butterworth-Heinemann, 2009

# Therapeutic Guidelines: Cardiovascular\*

*Psychotropic Expert Group.*

\*Version 5. xxii+243pp, paperback, ISBN 978-0-9804764-1-5. Melbourne, Therapeutic Guidelines Limited, AUD39.00, 2008.

Apart from textbooks, there have been few handbooks published specifically on cardiovascular guidelines. This fifth Version of Therapeutic Guidelines: Cardiovascular, part of a collection of 14 in the series of the popular and respected Therapeutic Guidelines series in Australia, is a major step forward in filling this gap. *Therapeutic Guidelines: Cardiovascular* has a table of Contents, list of Tables, boxes and figure, a list of the members of the Expert Group, Acknowledgments, a list of Endorsements, About Therapeutic Guidelines Limited and their Board of Directors, a Preface, 14 Chapters, two Appendices, a comprehensive Index and a Request for comment on guidelines proforma. It also includes 20 Tables, 14 Boxes and one Figure.

As is usual in this series, the handbook is compact and, if consistent with others in the series, the reader will expect that updated guidelines would be released every few years. The front cover has a basic but functional design. The back cover is virtually blank, except for the ISBN and barcode, and an opportunity has been missed to include a fast find contents list or an overview of the publication; however all of the Therapeutic Guidelines' handbooks seem to take this minimalist approach. Similarly, it may be interesting to make better use of the inside front and back covers, as has been done in other series, such as the Oxford Handbooks, by listing for example major emergencies and the page references to find information to manage them. Each chapter has a useful highlighting strip on the edges of the pages, which importantly helps to identify the various chapters, although they are not staggered, which defeats their purpose somewhat. It is also important to note that the handbook is also available electronically and this would make it very easy to print out patient information sheets, for example.

As an Australian based publication, it is inevitable that the writing group would be predominantly Australian. It is interesting however that all 15 members of the Cardiovascular Expert Group are Australian based. None-the-less, many of these experts would be well known in the cardiovascular field. Apart from the field of clinical pharmacology, there are one or two experts outside of cardiology from fields such as general practice. Cardiovascular guidelines for New Zealand are given elsewhere.<sup>1</sup>

*Therapeutic Guidelines: Cardiovascular* is well researched, concise and consistent in its presentation. Chapters include "Getting to know your drugs"; "Cardiovascular disease risk reduction", "Assessment and treatment of smoking", "Dyslipidaemia", "Hypertension", "Coronary ischaemic syndromes", "Heart failure", "Arrhythmias", "Venous thromboembolism", "Peripheral arterial disease", "Noncardiac surgery in patients with cardiovascular disease", "Syncope", "Hypertension and other cardiovascular disease in pregnancy", and "Pulmonary hypertension". There are also two Appendices, namely "Cardiovascular drugs used in pregnancy and breastfeeding" and "Useful sources of information". By far, the largest chapter is Chapter 1 "Getting to know your drugs" (pages 1-38). The drugs are discussed by sub-headings, namely "Mechanism of action", "", "Pharmacological properties", and "Adverse effects". The drugs covered include Angiotensin converting enzyme (or ACE) inhibitors, Angiotensin II receptor blockers, Beta blockers, Calcium channel blockers, Diuretics, Other antihypertensive drugs, Antiarrhythmic drugs, Nitrates, Nicorandil, Digoxin, Sympathomimetic drugs, Lipid lowering drugs, Anticoagulants, Antiplatelet drugs, Thrombolytic drugs, Drugs for nicotine dependence, Fish oil (omega-3 long-chain polyunsaturated fatty acids), Other drugs used in cardiovascular disease. There is no set pattern to the structure of the chapters and sections in the guidelines, although most sections cover prevention as well as management.

Version 5 is a major update of *Therapeutic Guidelines: Cardiovascular*. There is an increased emphasis on the prevention by both pharmacological and non-pharmacological means. There is a completed revised chapter on cardiovascular disease risk reduction (p 39-46), in particular emphasising lifestyle factors that may be addressed to assist in this risk reduction. It usefully lists agents that are no longer considered useful in risk reduction to help dispel any lingering myths. The guidelines emphasise also the need to make a risk assessment of every individual and does not promote a one approach fits all nor a "polypill" approach. Several chapter updates have just needed to keep pace with changes to Australasian and international cardiovascular guidelines, such as the chapters on hypertension, heart failure and venous thromboembolism (VTE). There have been some

significant changes to the treatment of pulmonary oedema and the increased use of low molecular weight heparin for VTE has been introduced. A very useful addition is the section on non-cardiac surgery for patients with cardiovascular disease—a challenge constantly being confronted by primary health care and by hospital medical staff (p 177-182). From the Australasian perspective, it is hard to fault the guidelines, although a more obvious multidisciplinary approach could have been adopted. One possible omission for those interested in travel and wilderness medicine would be a chapter on issues connected with travel and retrieval. Another possible omission is that there is no special compilation of the cardiovascular side-effects surrounding acute or chronic poisoning or envenomation, which might be found in a larger textbook. None-the-less, it is a very useful rapid therapeutic guidelines reference.

*Therapeutic Guidelines: Cardiovascular* is not a substitute for training and experience in cardiovascular medicine. It is also not meant to be a comprehensive textbook, especially as there have

been several good textbooks published, including a useful textbook based on extracted chapters on cardiovascular medicine from *Harrison's Principles of Internal Medicine*, which is a much anticipated first edition.<sup>2</sup> The handbook does however provide an exceptionally useful and fairly comprehensive clinical reference on most aspects of cardiovascular medicine for the informed health professional, particularly those who are working or will be working professionally in cardiology, general practice and related areas. The book will also appeal to general physicians and other health professionals, who have an interest in cardiovascular medicine, as well as students and academics involved in cardiovascular training courses. *Therapeutic Guidelines: Cardiovascular* has little competition in the guidelines field and is an important guidelines reference handbook in Australasia.

---

*Reviewed by: Peter A. Leggat, MD, PhD, DrPH, FAFPHM, FACTM, FACRRM, FFTM ACTM, FFTM RCPSCG, Professor and Head, School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Townsville, Queensland, 4811, Australia.*

### References

1. New Zealand Guidelines Group. New Zealand Cardiovascular Guidelines Handbook. A summary resource for primary care practitioners 2009 Edition. Wellington: Ministry of Health, 2009.
2. Loscalzo J. Harrison's Cardiovascular Medicine. 1st edn. McGraw Hill Professional, 2010 (scheduled for release in June 2010).

## 1. Purpose and scope

The Journal of Military and Veterans' Health is a peer reviewed journal published by the Australian Military Medicine Association. The aim of the journal is to promote excellence in the discipline of military and veterans' health, to promote research and to inform and educate all those practising as health professionals or who have an ongoing interest in this area. The scope of the journal covers all aspects of health of service personnel from enlistment and service within a military organisation to post service health care as a veteran. Environmental and related aspects of employment are included in this scope so that the journal provides a unique forum for discussion and research related to a wide range of health issues arising from exposure to military environments. This scope is very broad including, for example, mental health, trauma, health training and effects of environment on health.

### Editorial Office

Please address all non-electronic correspondence to:

Journal of Military and Veterans' Health  
113 Harrington Street  
Hobart TASMANIA 7000  
AUSTRALIA

Email: [editorial@jmvh.org](mailto:editorial@jmvh.org)

Tel: 613 6234 7844

Fax: 613 6234 5958

URL: <http://www.jmvh.org>

### Submission of manuscripts

Electronic submission of manuscripts is mandatory.

### Manuscript requirements

Manuscripts submitted to the Journal of Military and Veterans' Health must conform with the *Uniform requirements for manuscripts submitted to biomedical journals* ([www.icmje.org](http://www.icmje.org)).

## 2. Categories of manuscripts

The Journal of Military and Veterans' Health publishes articles related to health of military personnel and veterans within two broad areas of interest:

Research and practice related	Informative and commentary
Original Research/ Original Articles	Editorials
Short Communication	Letters to the editor
Review articles	Biographies
Reprinted Articles	History
Case Studies	Obituaries
Abstracts from the Literature	Book reviews
	Commentary
	View from the Front

Each issue may not contain all categories of articles. The word limit does not include text in the abstract, references, figures and tables. The requirements for submission categories, which are peer reviewed, are summarised below:

Category	Maximum word count	Maximum number of	
		Tables and/or figures	References
Editorials	1000	1	3
Original research	3500	6	30
Short communication	1500	3	10
Review article	5000	8	60
Case studies	1000	3	10
Letters to the editor	800	2	10
History	3000	6	20
Commentary	1500	3	10
View from the Front	2000	5	20
Obituaries	200	1	4

# Instructions to Authors

---

## Original research

This category is the primary mode in the journal for communication of findings from original research studies.

## Short communications

This category is for communicating the findings from small-scale research studies however other subject material will be considered.

## Review articles

Authors who wish to submit a review should first contact the editors to determine its suitability for publication in the journal. The editors encourage authors to submit systematic reviews for publication.

## Reprinted articles

This section will include full length copies of articles reprinted with permission from other journals. These articles must be keynote and valuable contributions to health issues in the military and veterans' areas. Readers are invited to email details of papers that should be considered for this category. Any proposal should be accompanied by a short commentary (maximum 200 words) outlining why this historical paper was important in shaping some aspect of military or veteran health practice. The commentary will be published with the keynote article.

## Case studies

This category is primarily designed to present details of interesting or unusual clinical cases and a summary is required with a limit of 100 words. The text should be presented using the following headings; background, history, examination findings, special investigations, discussion including differential diagnosis. The article should succinctly illustrate important points.

## Abstracts from the literature

This category will include abstracts of seminal work published in other journals which is related to the scope of the Journal of Military and Veterans' Health. Readers are invited to email references to papers that are considered to be valuable to healthcare professionals and others in the military and veterans domains. The editors acknowledge that many of our readers may not have facilitated access to comprehensive reference libraries.

## Letters to the Editor

Letters may comment on material that has recently been published in the journal or may address new topics, such as use of new equipment or instrumentation in

the field or a new technique applicable to preventive medicine. Where the subject matter is directed towards a previous publication the editors will usually send the letter first to the authors of the original paper so that their comments may be published at the same time as the letter.

## Editorials

Submissions are encouraged for publication in this category and these will be subjected to the peer review process. Topics of interest must fall within the scope of the Journal of Military and Veterans' Health. Guest editorials may be invited from time to time by the editor; suggestions for topics for editorials should be directed to the editor.

## Biographies

Biographical accounts of the work of individuals who have made outstanding contributions to the health and care of military personnel and veterans will be considered for publication. If you wish to submit a biographical article the editor should be consulted prior to preparation of the article. The editorial board may solicit such articles directly.

## History

Articles describing notable themes related to health and care of military personnel and veterans are invited for publication. The scope is broad and could include, for example, the conduct and outcome of military operations, effect of climate, improvements in trauma care, surgical techniques and mental health. The article should focus on health care delivery and practise as the main theme and may compare changes from earlier practise to those in use today. The editorial board may invite such articles directly however if you wish to submit a manuscript the editor should be consulted in advance. The style of this category will be the same as that applied to a review article.

## Obituaries

The editorial board will accept obituaries for individuals who have served as health professionals within the Australian Defence Force. These have been very successful in the British Medical Journal (BMJ) to provide information to the wider health readership. Guidance for preparing an obituary can be found on the BMJ web site, [www.bmj.com](http://www.bmj.com) (e.g. *BMJ* 1995;311:680-681 (9 September) and *BMJ* 1995;311:143-144 (15 July)). Obituaries should be submitted within one month of death and will be subject to editing if required.

# Instructions to Authors

---

## Book reviews

Reviews of publications which have a direct focus on military and veterans' health for educational, informative, reference or other reasons will be invited. The author/s would be expected to be independent, have considerable experience and/or a track record and a direct involvement in the field which is addressed by the publication.

## Commentary

Commentaries will be short articles which provide incisive, informative and balanced comment on current health issues. The editors may invite commentary on a research paper published in the same edition of the journal. All commentary articles will be peer reviewed and the article style will be that of an editorial.

## A view from the front

This category will consider submissions from health individuals at the front line of health care and health delivery to serving personnel and veterans. These articles should be topical, recent, may contain an individual's personal view of a health delivery system and will be subject to peer review.

## 3. Editorial policy

### Original material

The Journal of Military and Veterans' Health publishes original work describing health related research studies. Submitted manuscripts must not have been published or submitted for publication elsewhere, either in whole or in part. This applies to both paper and electronic methods of publication but not to abstracts presented to scientific meetings. Authors planning to submit review articles should first contact the Editorial Office to ensure the appropriateness of the subject material.

### Disclaimer

The articles and opinions expressed in this journal are those of the authors, and should not be taken as reflecting official government policy. While the Editorial Board makes every effort to ensure that no inaccurate or misleading data, opinions or statements are published in the journal, all data, results and opinions appearing in articles and advertisements are the responsibility of the contributor/s and/or the advertiser concerned. Accordingly the Editorial Board and their respective employees, officers and agents accept no liability whatsoever for the consequences of any such inaccurate or misleading data, results,

opinions or statements. While every effort is made to ensure that all data are accurately presented, new methods and techniques should only be considered in conjunction with published literature from manufacturers.

### Ethics approvals

All studies that involve participation of humans, information on participants or which would otherwise be considered to require ethical approval related to the principles set forth in the Helsinki Declaration should be conducted in accordance with such principles. Studies of this nature must contain a statement indicating that approval has been granted by a properly established Human Research Ethics Committee.

All studies involving experiments with animals must contain a statement indicating that the protocol *was approved by an appropriately constituted ethics committee or institutional review board in compliance with guidelines* established by that country's government. A statement must be included that indicates that all animals received humane care in compliance with these guidelines.

### Confidentiality

Confidentiality must be maintained in relation to all participants. All presented data must be de-identified. If a participant is able to be identified from illustrations, photographs, case studies or other study data then release forms or copies of permission for publication must be submitted with the manuscript.

All potentially identifying information (including patient likenesses, identification numbers, names and initials) must be removed from images, tables, graphs, charts and text before the manuscript is submitted.

If a reference is made in the text to personal communication (oral or written) as a source of information, a signed statement of permission is required from each source. The year of receipt of these statements should be provided in the text. Use of personal communication as a reference will only be accepted in special instances.

### Informed consent

A statement must be included indicating that informed consent was obtained from all participants if data were obtained from or were related to human participants.

### Authors Process form

Each author must complete this form and forward the original signed copy to the editorial office. A faxed or scanned image may be submitted electronically to

# Instructions to Authors

---

maintain the editorial process however the original completed form must be received by the editorial office before publication.

## Copyright assignment

Copyright for each submission is to be assigned to the Journal of Military and Veterans' Health or provision for a licensing arrangement must be completed (*Authors Process* form).

## Conflict of interest and funding

Authors are responsible for recognising and disclosing financial and other conflicts of interest that may bias or could be perceived to bias their work. They should acknowledge in the manuscript all financial support for the work including any control over publication by funding bodies and other financial or personal connections to the work. Each author must complete the conflict of interest and funding section of the *Authors Process* form.

## Authorship and acknowledgments

Each author must indicate their contribution to preparation of the manuscript (*Authors Process* form). The corresponding author is responsible for ensuring that all individuals who do not satisfy the criteria for authorship are noted in the acknowledgements section together with a brief description of their contribution.

## Sole submission

Authors must indicate that the work is original and has not been published or submitted for publication in another journal (*Authors Process* form) as the same or similar material. This includes submission by the authors and their colleagues in the interval before this work is published. Submission by authors of similar material to advertising, news media or other forms of publication must be indicated when the Journal of Military and Veterans' Health receives your manuscript and a copy of that material should be provided with your manuscript.

## Peer review

Two or more referees are assigned to review each submission (except for Book Reviews and Reprinted Articles). Acceptance of original articles is based on significance, originality, scientific quality and interest to the Journal of Military and Veterans' Health readership. If the submission is accepted for publication, editorial revisions may be made to aid clarity and understanding without altering the meaning. Authors are given the opportunity to nominate reviewers whom they believe are expert and impartial in their area of interest.

## Offprints

A copy of the final paper will be provided to the corresponding author in pdf format. A copy will be available from the journal website ([www.jmvh.org](http://www.jmvh.org)) for interested individuals to download. These copies are made available for single, personal use only and are not available for commercial or other use.

## Rights and permissions

Written permission to reproduce any previously published tables or figures must be obtained from the copyright holder (and authors as applicable) and a copy of this permission provided with your submission. Any reproduced material must be clearly identified and its source and permission noted in the manuscript.

## Clinical trial registration

We define a clinical trial as "Any project that prospectively assigns human subjects to intervention and comparison groups to study the cause-and-effect relationship between a medical intervention and a health outcome (ICMJE definition). These should be registered, including early phase uncontrolled trials (phase I) in patients or healthy volunteers (WHO Recommendation)".

The Journal of Military and Veterans' Health requires all clinical trials to be registered with a registry that is accessible to the public (at no charge); is searchable using standard, electronic (internet) means; is open to all prospective registrants at minimal or no cost; validates registered information; identifies trials with a unique number; and includes basic information related to the researchers and the trial.

If you are submitting a randomised controlled trial, add the registration number of the trial and the name of the trial registry in the acknowledgements section of your manuscript. Other trial registers that currently meet all of the International Committee of Medical Journal Editors (ICMJE) and World Health Organization (WHO) requirements can be found at <http://www.icmje.org/faq.pdf>.

Registries that meet these criteria include:

- Australian Clinical Trials Registry ([www.actr.org.au/](http://www.actr.org.au/))
- US National Library of Medicine (sponsor) ([www.clinicaltrials.gov](http://www.clinicaltrials.gov))
- The International Standard Randomised Controlled Trial Number registry ([www.controlled-trials.com](http://www.controlled-trials.com))

# Instructions to Authors

---

- The National (UK) Research Register ([www.update-software.com/national/](http://www.update-software.com/national/))
- European Clinical Trials Database (<http://eudract.emea.europa.eu/>)

## Language

All manuscripts must be written in English. Spelling and phraseology should be to either standard English or standard American usage and should be consistent throughout the manuscript. Contributors with a non-English native language are encouraged to seek the help of a competent linguist who is familiar with medical terminology prior to submission. It is the author's responsibility to have the language revised before submitting the work for publication. Only minor language revisions are provided after submission.

## Review process

Receipt of all submitted papers is acknowledged by email. Manuscripts are initially assessed by the editors and then sent for external review to experts in the field. The corresponding author will be notified by email when a decision is reached. To aid in the peer review process we invite authors to suggest potential reviewers, with their contact details, in the cover letter.

## Reproduction of articles, figures and tables

If you would like permission to reproduce an item from material published by the Journal of Military and Veterans' Health, contact the editorial office by email [editorial@jmvh.org](mailto:editorial@jmvh.org).

## Software and format

The manuscript must be supplied in Microsoft Word in .doc format (Word 2007 file format not accepted at this point in time) or in rich text format. Files prepared in other packages will only be accepted and considered provided they are compatible with Microsoft Word and that *any reformatting is minor*. Files prepared in various desktop publishing proprietary formats will not be accepted.

## 4. Organisation of manuscripts

Papers will differ in structure depending on category. These instructions refer to sections of manuscripts independent of category where these sections are included. For original research articles the structure should follow the order below with each section beginning on a new page. Reviews should commence with an abstract and then be organised such that the information is presented in a logical sequence with

informative headings and sub-headings related to the content.

## Title page

The manuscript should be preceded by a title page which includes the following information:

- Concise title of manuscript
- Name, address, title, highest qualification, affiliation and contact details (email, postal address, telephone and fax) for each author
- Identify corresponding author
- Identify (email) address for correspondence (corresponding author)
- Short running title (maximum 50 characters including spaces)
- Word count (text of paper only – excludes abstract, references, figures and tables)

## Abstract

The abstract for original articles should be structured under the following headings: Background, Purpose, Material and Methods, Results, Conclusion. The Background must be a maximum of two sentences. Maximum length of the summary should be 250 words with three to five key words or phrases included below the abstract or summary.

## Conflict of Interest

All conflicts of interest must be disclosed in full in this section of the manuscript. These may include, but not be limited to, specific or "in kind" interests, incentives and relationships in respect of the manuscript (e.g. grants, funding, honoraria, stock ownerships, royalties, payment of expenses). This section applies to all authors.

## Introduction

It should be assumed that the reader does not have a comprehensive knowledge in the field and you should therefore provide a concise account of the background (including relevant literature references) and reasons for this study.

## Materials and methods

Descriptions of any techniques and methods must provide sufficient detail such that a reader can replicate the procedures. Methods that have been published elsewhere should not be described in detail and should be referenced to the original work

*Statistics.* A full description of the statistical methods used should be provided.

# Instructions to Authors

---

## Results

Description of results, while concise, should permit repetition of the procedures and direct comparison with similar data by others. Data should not be repeated unnecessarily in the text, figures and tables and appropriate selection of significant figures for numerical data presentation should be applied. Significance should be expressed as values of probability. Where appropriate, results should be presented as figures rather than tables of data.

## Discussion

The discussion should not simply reiterate the results presented; the authors should present their analysis and conclusions with reference to the current knowledge base related to this work. Any assumptions on which conclusions may be based should be stated and there should be some discussion of strengths and weaknesses of the research.

## Acknowledgements

These should be brief and should include references to sources of support including financial, logistical and access to material not commercially available. Any individuals named must be given the opportunity to read the paper and approve their inclusion in the acknowledgements before the paper is submitted.

## References

A list of references should be provided starting on a new page. Only published references or those genuinely in press should be included.

## Tables (including legends to tables)

Tables are to be placed at the end of the manuscript in order of appearance in the text with one table per page. Captions to tables should be short and concise, not exceed one sentence and be on the same page as the table.

## Illustrations

These are to be submitted as a separate electronic file for each image.

## 5. Preparation of manuscripts

### Style

*References.* A standard English dictionary should be used (e.g. Oxford English Dictionary 2007) for spelling or hyphenation of non-medical terms and Dorland's Illustrated Medical Dictionary (WB Saunders, Philadelphia) is recommended for medical

terms. A source for general style including grammar, punctuation and capitalisation is the *Style manual for authors, editors and printers*, Sixth edition 2002 (John Wiley and Sons, Australia).

*Numbers.* Use numerals for all units of measure and time and for all sets of numbers (e.g. 1 m, 2 hours, 5 years, 4%, 2 of 6 observations). Spell out the numbers one through nine only for general usage (e.g. "we had two opportunities"). Spell out numbers beginning a sentence.

*Abbreviations.* Abbreviations should be kept to a minimum to avoid confusion with readers who may not be familiar with the subject material. Only standard abbreviations, as listed in a style manual or accepted internationally for use within a subject area, may be used without definition. Terms used frequently within a manuscript may be abbreviated however these should be spelled out at first citation with the abbreviation in parenthesis. Abbreviations in speciality areas must conform to accepted use in that area.

*Layout.* Headings and sub-headings should be consistent throughout the article and conform to the style used in articles previously published in the journal. No text should be underlined. Prepare the manuscript with double-spacing and allow margins of 2.5 cm.

### Tables

Tables should be on separate pages at the end of the paper (following the References section) and be capable of interpretation without reference to the text. They should be numbered consecutively with Arabic numerals (e.g. Table 1). A concise, descriptive caption must be provided for each table. Units in which results are expressed should be given in brackets at the top of each column and not repeated on each line of the table. Ditto signs are not acceptable. An indication should be provided in the manuscript as a guide to indicate where the table should be inserted.

### Image files

All images must be submitted as separate files. Images embedded in word processing files are not acceptable. Each image must be referred to in the text and an indication should be provided in the text as to the preferred position of the image. Lettering and lines should be of uniform density and the lines unbroken. Image size and layout should be constructed so that each can be placed within a single column or page width.

At submission all files must satisfy the following criteria for resolution, file format and file size and be

## Instructions to Authors

---

submitted in the actual size to be used. Image width should be constructed to be either one or two column width.

- Halftone images  
600 dpi
- Colour images  
400 dpi (saved as CMYK)
- Images containing text  
600 dpi
- Black and white line art  
1200 dpi
- File types  
TIF, EPS (JPG and GIF are not suitable)
- Figure width (single column)  
-- mm
- Figure width (double column)  
-- mm
- Font size  
8 point (must be readable after reduction)
- Font type  
Times, Times New Roman, Helvetica, Arial
- Line width  
Between 0.5 and 1.0 point

*Illustrations.* These should be referred to in the text as figures (e.g. Figure 1) and numbered consecutively with Arabic numerals. Photographs and illustrations will only be accepted as digital images and should be either composed or cropped before submission to ensure there is no unwanted material in the frame. Digital files judged to be unacceptable in the review process must be resubmitted by the authors.

*Graphs, charts and figures.* All graphs, charts and figures must be submitted in electronic format (.EPS or .TIF files) and should be prepared by a suitable software package. These should be referred to in the text as figures (e.g. Figure 1). Images of hand drawn material will generally not be accepted. Symbols which are to appear in the figure (and not in the caption) should be chosen from the following available types:

• ○ ■ □ ▼ ▲ ◆ ◇ + Δ

### Footnotes

The following symbols should be used in the order given to reference footnotes:

\*, †, ‡, §, ||, ¶, \*\*, ††, ‡‡

### References

The list of references should appear at the end of the manuscript. References should be numbered consecutively in the order in which they are first mentioned in the text. References in text, tables and legends should be identified by Arabic numbers and appear in the text in superscript, for example text<sup>1</sup> or text<sup>2-4</sup> or text<sup>5,6-7</sup>. Where punctuation (e.g. comma, period) follows a reference number then the punctuation should appear after the reference.

The format of references should follow the "Vancouver" style as described in the *Uniform requirements for manuscripts submitted to biomedical journals* ([www.icmje.org/](http://www.icmje.org/)). The Journal of Military and Veterans' Health varies in two respects from these guidelines: Surnames and initials of no more than the first three authors [et al.] are cited and the first and last page numbers of a reference are cited in full. Journal names should be abbreviated as accepted in Index Medicus (<http://www.nlm.nih.gov/tsd/serials/lji.html>) and a period is not used after journal name abbreviations (e.g. J Mil Vet Health). A list providing detailed examples of references for many types of publication is available at [http://www.nlm.nih.gov/bsd/uniform\\_requirements.html](http://www.nlm.nih.gov/bsd/uniform_requirements.html). Where appropriate, cite the type of reference (e.g. letter, editorial, abstract or supplement).

Authors should verify references against the original documents and are responsible for checking that none of the references cite retracted articles except in the context of referring to the retraction. For articles published in journals indexed in MEDLINE, the International Committee of Medical Journal Editors considers PubMed (<http://www.ncbi.nlm.nih.gov/sites/entrez/>) the authoritative source for information about retractions. Authors can identify retracted articles in MEDLINE by using the following search term, where pt in square brackets stands for publication type: Retracted publication [pt] in pubmed.

An example of the reference system is as follows:

1. Quail G. Asthma in the military. *Aust Mil Med* 2000; 9(3):129-137.

### Units of measurement

The International System of Units (SI) must be used. For values less than zero enter a zero before the decimal point e.g. 0.123. The style should include a solidus e.g. mg/L.

## Abbreviations

Use of abbreviations should be minimised. Spell out non-standard abbreviations at their first mention in the text followed by the abbreviation in parentheses. Avoid uncommon abbreviations and jargon.

## 6. Checklist

Check the following items before submitting your manuscript.

- Covering letter
- Authors Process Form completed by all authors
- Copy of permission to publish material from other sources (copyright holders)
- All individuals named in Acknowledgements have read the paper and approved their inclusion.
- Copy of all permissions to reproduce material from other sources
- All graphs, charts and figures as separate files, referred to in text of paper and position in paper identified
- All illustrations as separate files, referred to in text of paper and position in paper identified
- All tables included, referred to in text of paper and position in paper identified
- Permission obtained for use of *Personal communication* as a reference
- Copies of any part of the manuscript that may have been published previously
- Copies of any advertising or other material that includes any of the submitted material or data
- Statement on ethics approval/s included

## 7. Submission of manuscripts

### Covering letter

Your covering letter should be submitted electronically with the manuscript as a separate file. It can contain author identifying information as it will not be shown to peer reviewers. It should include:

- Why the paper should be published in the Journal of Military and Veterans' Health
- Details of suggested reviewers

### Proofs

Proofs will be sent in electronic form as a PDF to the corresponding author who should read them carefully. Major alterations to the text cannot be accepted at this stage. The proofs should be corrected and returned to the Editorial Office by fax or email (image) within 48 hours of receipt.

### Software file requirements

The software files must be named so that each is uniquely identified and attributable to your submission. All files submitted should be named to include the following information in the order below:

- Corresponding author surname
- Corresponding author initials
- Title of paper (may be abbreviated)
- Supplementary identifier to indicate contents of file (e.g. for a figure, include *figure* and unique identifier which can be related to that figure).

### Examples:

Quail G Asthma in the military Text of paper.doc  
Quail G Asthma in the military Figure 1.eps

### Electronic submission of paper

The files can be compressed using a .zip compression format. File size must not exceed 10 Mb for a given email. If there are file size concerns contact the Editorial Office.

# Copyright Policy

---

Journal of Military and Veterans' Health (JMVH)  
Author Process Form

Each author must read the authorship, licence to publish, conflict of interest and acknowledgements sections of this form and then acknowledge agreement with each section by ticking the check boxes. The corresponding author must also read and sign the statement on the acknowledgements section. Original signed copies of the form must be sent to the JMVH 113 Harrington Street, Hobart.

Your Name (Print): \_\_\_\_\_

Manuscript Title: \_\_\_\_\_

Email: \_\_\_\_\_

Telephone: \_\_\_\_\_

Fax: \_\_\_\_\_

Corresponding Author: \_\_\_\_\_

1. Authorship. Each author must acknowledge their contributions by checking the appropriate statement. An individual must be able to check all boxes in this section to qualify as an author.

I certify that:

- The manuscript presents original, accurate and valid results. I accept responsibility for all subject material and data on which the manuscript is based and for the integrity and veracity of this paper and its conclusions. I may be called upon to defend the veracity of this paper, should it ever be questioned or criticized in part or in full.
- The manuscript has not previously been published (except in abstract form), in part or in total and has not been submitted elsewhere for publications (attach a letter of explanation if part or wholly submitted elsewhere).
- The manuscript shall not be published elsewhere in any language without written consent of the journal and will not be stored electronically or otherwise in any form without consent of the journal.
- If the manuscript has more than one author, the corresponding author nominated above will communicate with the JMVH editorial office to review edited proofs and make decisions regarding the manuscript.

I certify that I have made substantial contributions to the intellectual content of the manuscript for all of the following:

- Conception and design of the study or analysis and interpretation of data.
- Drafting or critically reviewing the manuscript for intellectual content.
- Giving approval of the submitted manuscript.

2. Licence to Publish. Check the appropriate box:

I certify that JMVH has been assigned an exclusive *Licence to Publish* the manuscript in part or in total in printed and electronic form. This licence shall include all parts of the manuscript including text, tables, figures, video, audio and any other related material as:

The copyright belongs to me.

The copyright belongs to my employer from whom I have obtained written permission for a *Licence to Publish*.

The copyright belongs to the funding body/bodies for this work from whom I have obtained written permission for a *Licence to Publish*.

The copyright for the manuscript and its content belongs wholly in the public domain and no *Licence to Publish* is required.

3. Financial Disclosure and Conflict of Interest. Check one of the boxes below as applicable. The statements refer to the previous five years and the foreseeable future.

I certify that:

I have no conflict of interest including but not limited to specific financial incentives, relationships or affiliations and have received no "in kind" considerations in relation to this manuscript

OR

I have disclosed all conflicts of interest including but not limited to specific or "in kind" interests, incentives and relationships in respect of the manuscript (e.g. grants, any control of publication by funding body, honoraria, stock ownerships, royalties, payment of expenses) and these are disclosed in full in the Conflict of Interest section of the manuscript.

\_\_\_\_\_  
Your Signature

\_\_\_\_\_  
Date

4. Acknowledgements Section. I certify that (both boxes must be checked):

Written permission has been provided by all individuals noted in the Acknowledgements section of the manuscript.

All individuals who have made a significant contribution to the content reported in this manuscript but who do not satisfy the criteria for authorship are noted with their specific contributions described.

\_\_\_\_\_  
Corresponding Author Signature

\_\_\_\_\_  
Date



# WARRIOR HEALTH

2010 AMMA/JOINT HEALTH COMMAND SYMPOSIUM

REGISTRATION NOW OPEN

Online at [www.amma.asn.au](http://www.amma.asn.au)



29 - 31 OCTOBER 2010  
NATIONAL CONVENTION CENTRE, CANBERRA ACT



**DISCLAIMER**

The views expressed in this journal are those of the authors, and do not reflect in any way official Defence Force policy, or the views of the Surgeon General, Australian Defence Force, or any Military authority

[www.jmvh.org](http://www.jmvh.org)