Centre for Military and Veterans' Health *Volume I* **The Middle East Area of Operations (MEAO) Health Study:** *Prospective Study Report*

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Abbreviations

ADF	Australian Defence Force	
ADHREC	Australian Defence Human Research Ethics Committee	
AUDIT	Alcohol Use Disorder Identification Test	
CI	Confidence Interval	
CIDI	Composite International Diagnostic Interview	
СМVН	Centre for Military and Veterans' Health	
DAR	Dimensions of Anger Reactions	
DHSP	Deployment Health Surveillance Program	
DMAC	Data Management and Analysis Centre	
DSM-IV	Diagnostic and Statistical Manual Version 5	
DVA	Department of Veterans' Affairs	
IED	Improvised explosive device	
K10	Kessler Psychological Distress Scale	
mTBI	Mild traumatic brain injury	
MEAO	Middle East Area of Operations	
MilHOP	Military Health Outcomes Program	
NCO	Non-commissioned officer	
NNAI	Near North Area of Influence	
OR	Odds ratio	
PCL-C	Post-traumatic Stress Disorder Check List – Civilian	
PMB	Program Management Board	
PHQ	Patient Health Questionnaire	
PTSD	Post traumatic stress disorder	
RAAF	Royal Australian Air Force	
RAN	Royal Australian Navy	
SAC	Scientific Advisory Committee	
UA	University of Adelaide	
UK	United Kingdom	
UQ	University of Queensland	
US	United States	

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Chapter One – Introduction

Key Points

- 1. Australia has now been at war in Afghanistan for over a decade and more than 24,000 Australian troops have been deployed, many of whom are assigned to combat roles.
- 2. There is now a substantial body of research which demonstrates how repeated exposures to trauma over a prolonged period increase the risk of morbidity and even mortality.
- 3. A number of factors have limited the potential for other studies to investigate the health outcomes associated with the types of traumas these troops may experience, including:
 - the collection of data many years after deployment,
 - research that is undertaken in an environment of mistrust and intense media interest,
 - poor recruitment rates for comparison groups; and
 - no available baseline data from which to assess the extent of any changes to health outcomes.
- 4. The design of the MEAO Prospective Study overcomes these issues, and thus is able to provide a unique insight into the long-term impact of combat exposure and deployment on the health of Australian Defence personnel.

1.1 Introduction

Australia has now been at war in Afghanistan for over a decade, twice the duration of World War II, and over 25,000 Australian troops have now deployed to the MEAO. Many have deployed several times. While to date no estimate has been made of the potential health costs to the DVA in Australia, the potential health costs of the United States of America engagements in Iraq and Afghanistan could exceed \$900 billion [1 pp 214-221].

War results in adverse health outcomes above and beyond just acute combat related injuries [2]. Butler's [3] history of the Australian Imperial Force Medical Corp in World War I reported an increase in what was referred to as "the burnt out soldier effect". Similarly the impact of combat exposure on the Canadian forces in World War I has also been observed [2]. A longitudinal study of Harvard sophomores who were recruited in 1938 and followed on an annual basis [4], also demonstrated an increase in disease and premature mortality in the group who had high combat exposure in World War II.

More recently, a range of non-battle injuries have been linked to combat. Psychiatric disorders including depression, post-traumatic stress disorder (PTSD) and anxiety, as well as somatic conditions such as chronic fatigue syndrome, fibromyalgia and chronic pain, are suggested to be related to combat stress. However, it is also possible that that these symptoms relate to other unanticipated environmental

exposures; thus monitoring is necessary so as not to miss any of the health consequences associated with deployment.

The focus of veteran health research in Australia has also changed. Emerging concerns about the health of veterans following deployment has led to the ADF and DVA commissioning studies which examine cohorts of veterans who have voiced particular health concerns. These studies are critical to the effective administration of the Repatriation Commission. Studies of veteran groups to date include the Vietnam War [5], Korean War [6], the Gulf War 1990-91 [7], Peacekeepers (current), East Timor [8], the Solomon Islands [9] and Bougainville [10]. Additionally, the research into illness and pathways to disease can inform departmental program and policy development.

1.2 Longitudinal Trajectories and Common Pathways to Disease

There is now a substantial body of research demonstrating how repeated exposures to trauma over a prolonged period increase the risk of morbidity and even mortality [11]. This is particularly relevant to military personnel who often experience multiple trauma exposures through combat. Referred to as sensitisation, the suggestion is "...that individuals who are repeatedly exposed to an environmental risk factor may develop progressively greater responses over time, finally resulting in a lasting change in response amplitude" [12 pp 220-221].

Heim et al. [13] described how the process of sensitisation arising from multiple trauma exposures is supported at a biological level. Core underlying biological systems that are often involved include inflammatory mediators, glucose metabolism, lipid metabolism, cardiovascular regulation, and neurobiological systems that mediate the central nervous and neurohormonal systems. One model that has been proposed to characterise the dysregulation of these systems has been referred to as "allostatic load".

Allostatic load refers to the wear and tear on the body in response to repeated cycles of stress [14, 15]. The physiological dysregulation that underpins allostasis represents a final common pathway to disease that can manifest in various ways, influenced by the interaction with other personal and environmental risk factors for disease. This model is a specific example of how a number of the conditions associated with adverse health outcomes following deployment probably share underlying patho-physiology.

1.3 The Methodological Challenges and Research Agenda

Few studies have collected a range of objective physiological, biological, immunological and hematological measures either after deployment, or more importantly before deployment, for comparison. Instead, many studies have relied on self report data which inevitably introduces potential errors and biases.

There are, however, a number of other factors which limit the value of previous veteran health studies. First, several veteran health studies occurred many years after the particular deployment ended; such as was the case for veterans of the Vietnam War and Korean War [16]. Even for the Gulf War 1990-91 the first data collection for Australian veterans occurred more than 10 years after the end of hostilities [17]. In addition to the retrospective reporting of exposures, this type of

research was often undertaken in an environment of mistrust with intense media interest, which also played a role in the interpretation and reporting of results [18].

Second, many of these studies were marked by poor recruitment rates, especially for comparison groups, recall bias, and poor ascertainment of health outcomes [19]. Third, none of these studies commenced prior to the deployments. In particular, there has generally been a significant lag between the period of deployment and data collection, which is less than satisfactory and adds to problems with sampling and recall bias.

Finally, as a consequence of the lessons from the Gulf War 1990-91, the veteran health research agenda in relation to the Iraq and Afghanistan Wars, especially in the US, has been more proactive, beginning during deployment, and covering a wider range of potential health outcomes of direct relevance to the nature of the deployment. Our allies have moved towards newer research methods, such as using prospectively collected data to document shifts in rates of disease over time, during and immediately following deployment [20]. However these strategies remain inadequate as many do not collect baseline data prior to deployment.

A turning point in the planning and conduct of veteran research followed the emerging findings from the Gulf War 1990-91. In the aftermath of that war, a large population of veterans from various allied countries were concerned that biological and chemical exposures could lead to a "Gulf War Syndrome". An extensive investigation of these issues and the published research literature by independent bodies, such as the Institute of Medicine in the United States (US), concluded that no specific syndrome existed [18]. Rather, the systematic review conducted by the Institute of Medicine expert panel [21] found three groups of disorders which were of crucial interest and thus demand further research.

1. Disorders with Sufficient Evidence of an Association

Conditions where there was a consistent positive association observed between deployment to a war zone and a specific health effect in human studies, and confounders could be ruled out with reasonable confidence. These included psychiatric disorders, such as PTSD, alcohol abuse, other anxiety disorders, and depressive disorders.

2. Disorders with Limited but Suggestive Evidence of an Association

Conditions where evidence from available studies suggested an association between deployment to a war zone and a specific health effect, but where the body of evidence was limited by the inability to rule out chance and bias. These included chronic fatigue syndrome, gastrointestinal symptoms consistent with functional gastrointestinal disorders, such as irritable bowel syndrome or functional dyspepsia, skin disorders, fibromyalgia and chronic widespread pain. Not only did they believe that the etiology of these functional syndromes was poorly understood and needed to be studied further, but the role of infections and vaccinations warranted further investigation.

3. Disorders that had Inadequate/Insufficient Evidence to Determine Whether an Association Exists

Conditions where the evidence from available studies was of insufficient quantity, quality, or consistency to permit a definitive conclusion regarding the existence of an association between deployment to a war zone and a specific health effect. These conditions included diabetes mellitus, neurocognitive effects, hypertension, coronary heart disease, chronic respiratory effects and reproductive effects. The prevalence of these disorders in community samples, and the range of etiological factors other than deployment, meant that defining causal relationships posed a particular challenge.

The emerging literature and concurrent documentation of health hazards in the MEAO combat zones of Iraq and Afghanistan, other exposures and potential adverse health outcomes have also been identified, above and beyond the findings from the Gulf War 1990-91. These included the impact of dust exposure that may contain faecal material, exposure to blast injury leading to mild traumatic brain injury, and heat stress. In particular, mild traumatic brain injury has been of particular concern [22], hence it was critical that systematic surveillance was conducted both into the causes of mild traumatic brain injury and its impact on cognitive functioning and other symptomatic outcomes.

1.4 The MEAO Prospective Study

The MEAO Prospective Study provides a unique insight into the long-term impact of combat exposure and deployment on the health of Defence personnel. The findings may prove to be invaluable in better understanding the mechanisms involved in the onset of the physical and psychological problems that are known to emerge in the years following deployment.

While subsequent chapters in this section of the report will discuss in detail previous military studies of relevance, as well as the specific aims, methodology, and the findings of the MEAO Prospective Study, the general hypotheses investigated by the study are that:

- 1. traumatic exposure will predict the greatest post-deployment dys-regulation in individuals who had little or no evidence of significant dys-regulation prior to deployment,
- 2. prior to deployment there will be significant differences in dys-regulation determined by previous deployments, trauma exposure and other lifetime experiences,
- 3. individuals with the greatest degree of pre-deployment dys-regulation will be most vulnerable to combat stresses on deployment, with both adverse physical and psychological health consequences,
- 4. the range of non-specific symptoms typically associated with postdeployment syndromes (somatic symptoms) will predict the degree to which underlying biological systems are dys-regulated; and
- 5. the range of psychological symptoms will also predict the degree to which underlying biological systems are dys-regulated.

The methodology was designed to test these hypotheses overcomes the limitations seen in other veteran health studies in several ways. First, a longitudinal methodology was used to capture the trajectories of symptoms and the underlying biological mechanisms over time [23]. Data was collected immediately prior to deployment (baseline) and then again approximately four months post-deployment in order to reduce the risk of recall bias.

Second, rather than focusing on specific disease outcomes, the MEAO Prospective Study investigated the progressive sensitisation of the biological systems of interest that may predict future risk. Included within this investigation is the development of an allostatic load model which provides an early marker of the risk for future morbidity or mortality.

Third, while many previous studies have been prompted by ad hoc reports of unspecified ill health, such as Gulf War Syndrome, or by concern about specific chemical and other hazards, such as Agent Orange in Vietnam [24], the MEAO Prospective Study focused on a range of potential health outcomes of direct relevance to the nature of the deployment including those identified by the Institute of Medicine [21]. Finally, rather than relying solely on subjective assessments, the MEAO Prospective Study collected objective health measures prior to and again after deployment in order to identify early markers of the psychological and physical impacts of combat stress and the other exposures of interest.

The remaining chapters in this section continue to focus on the challenges of designing a longitudinal health study involving military populations. In particular, Chapter Two describes a number of similar longitudinal studies, which have already been conducted by Australia's coalition partners. Subsequent chapters within this Introductory Section describe the methods and measures used by the MEAO Prospective Study to capture both self-report and objective data (Chapter Three), and the final response rates and primary characteristics of the MEAO Prospective Study sample (Chapter Four).

Sections two to six of the report then present and discuss the primary findings of the MEAO Prospective Study, including:

- Psychological Health Outcomes in Section Two,
- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five

Finally, the conclusions and limitations of the study conclude the MEAO Prospective Study report in Chapter Twenty Two.

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Chapter Two - Background

Key Points

- 1. MEAO Prospective Study is the first study to consider the health of Australian military personnel from a longitudinal perspective.
- 2. The prospective design employed by the MEAO Prospective Study overcomes many of the challenges faced by longitudinal health studies conducted by Australia's coalition partners, including:
 - lag times between the deployment exposures and data collection,
 - · bias which is sometimes introduced with self-report data; and
 - a limitation on the range of health outcomes which were considered.

This chapter begins by describing a number of other longitudinal health studies involving military populations which have been conducted by Australia's coalition partners. In particular, the methodology employed, primary findings of interest, as well as some of the challenges that our coalition partners have faced are discussed. The chapter then provides details pertaining to the primary aims of the MEAO Prospective Study, and briefly describes the positioning of the study within the larger Military Health Outcome Program (MilHOP) and the Deployed Health Surveillance Program. Subsequent chapters within this Introductory Section then detail the methods and measures used to capture the objective and self-report data (Chapter Three), before presenting the response rates and primary characteristics of the MEAO Prospective Study sample (Chapter Four).

2.1 Longitudinal Military Studies

While the **MEAO Prospective Study is the only longitudinal Australian study which has collected mental, physical and social health data of deploying ADF members**, a number of longitudinal studies conducted by Australia's coalition partners have already been conducted.

2.1.1 United States of America

The US has been at the forefront of this work, the largest being the Millennium Cohort Study.

2.1.1.1 Millennium Cohort Study

Perhaps one of the most widely cited longitudinal bodies of research is the Millennium Cohort Study. This study has two primary aims – to evaluate the health of service personnel throughout their military career, and to determine whether deployment-related exposures are associated with post-deployment health outcomes [1]. The first data collection occurred in July 2001 when approximately 2.2 million men and women on active service rosters as of October 1, 2000, were invited to complete a self report survey which used a number of instruments to assess physical and functional status as well as PTSD, alcohol and tobacco usage, sleep patterns and various exposures. This subjective data was linked to Department of Defence inpatient, ambulatory and pharmacy databases in order to ensure that some objective measures of health were also captured.

Enrolment for this first panel ended in July 2003 with 77,047 responses (~37%). A preliminary analysis of this first wave of data showed, for example, that over 90% of the responders rated their general health as good or excellent and only 3.3% reported symptoms consistent with a major depressive disorder, 1.2% with a panic syndrome and 2.4% with PTSD [2]. In addition to following up these participants every three years, two further enrolment phases have occurred. Between 2004 and 2006 a further 31,110 and between 2007 – 2008 another 43,430 US military personnel were enrolled in the Millennium Cohort study. By the end of 2008, a further 63,590 participants had enrolled in the study, and completed baseline data collection and at least one follow-up [3, 4].

The Millennium Cohort Study has already addressed a number of health issues relevant to deployed personnel including the risk of PTSD and/or depression [5-9], alcohol misuse [10] and mild traumatic brain injury (mTBI) [11, 12]. In addition, the Millennium Cohort Study has addressed issues pertaining the physical health of deployed personnel such as respiratory health [13], hypertension [14] and health outcomes associated with the use of vaccines [15-17].

Key findings to date specific to deployment and combat exposures pertain primarily to mental health [18] including increased risk for new-onset depression [19], increases in various forms of alcohol misuse in both reserve and regular personnel [20] and an increased risk of new-onset PTSD symptoms [21], with prior lifetime traumatic experiences increasing this risk again [6]. In addition, key findings from the Millennium Cohort Study which apply to deploying personnel also include the increased rates of smoking in this cohort [22], increases rates of respiratory symptoms and newly reported hypertension specific to those who report multiple combat exposures, especially witnessing death due to war [14].

While the extensive Millennium Cohort Study database is a valuable source of data which will continue to be used to guide policy-makers for years to come [4], the longitudinal methodology employed by the study does not ensure the collection of data prior to and immediately after deployment. As was discussed in Chapter One, a lag between deployments and data collection increases the possibility of recall bias, and at the same time reduces the researchers' ability to relate particular health outcomes to deployment experiences. In addition, the objective data captured in this study is limited to the Department of Defence inpatient, ambulatory and pharmacy databases.

2.1.1.2 Marine Resilience Study

The Marine Resilience Study [23] was specifically designed to prospectively study factors which are likely to predict, as well as protect against the development of PTSD. A range of objective data were captured at each time point including information from medical records; biological measures such as blood, urine and saliva samples; neurocognitive performance measures; psychiatric assessments from clinical interviews; and genetic material. Data collection at each time point also included a self-report questionnaire which aims to capture demographic and family history information, and includes a number of validated scales aiming, among other things, to measure social support, conflict management, psychological symptoms and life events.

Between 2008 and 2010, baseline data from approximately 2,600 US marines in four battalions deployed to Iraq or Afghanistan was captured prior to deployment (Time 1). Data is also being captured 1 week after returning from deployment (Time 2), as well as 3 months (Time 3) and 6 months (Time 4) post-deployment.

Analysis of pre-deployment data showed 51.3% had at least one prior deployment, and that 60.5% of participants reported prior head injury, 56.9% with loss of consciousness. In addition, 7.4% of the Marines enrolled in this study met the criteria for at least one mental health diagnosis. The primary findings from baseline data were that over 7% of participants had at least one mental health diagnosis at baseline and that there was a moderate positive relationship between deployment history and PTSD prevalence [14]. Findings from the follow-up phase of the study are due shortly.

While the Marine Resilience Study collected a comprehensive set of objective psychological, cognitive, and physical health measures, the analysis is limited to one particular health outcome, namely PTSD. However, similar to the MEAO Prospective Study, data collected prior to and again post-deployment provided an opportunity to identify whether any changes in PTSD symptoms were likely to be associated with deployment experiences.

2.1.2 United Kingdom

King's Centre for Military Health Research has also undertaken a longitudinal study of UK personnel who deployed to either Iraq or Afghanistan. The first stage of the study [24] aimed to identify differences in mental and physical health outcomes between United Kingdom (UK) military personnel who had deployed to Iraq as part of Operation TELIC 1, and personnel who were not deployed as part of this operation but may have later deployed as part of TELIC 2 or 3 (comparison group). Just over 60% (n = 4722) of a group of randomly sampled eligible regular and reserve members who had deployed, completed a self report questionnaire. In addition, approximately 55% (n = 5550) of the eligible era population also completed a self report questionnaire. Data including demographics, service information, life experiences, deployment experiences (for deployed group), current health status and past medical history, were collected for both groups between January and June 2003.

Data collection for the second stage of this study occurred between November 2007 and September 2009 in order to identify whether deployment to Afghanistan, an increased intensity of fighting, and/or multiple deployments lead to an increase in the frequency of mental disorders [25]. This part of the study sampled three distinct groups. First, participants in stage one were recontacted and invited to complete a follow up questionnaire. In addition, 1789 UK military personnel who had deployed to Afghanistan (Herrick sample) and 6628 UK military personnel who had joined the military since stage one (replenishment sample) were included.

Similar to the Millennium Cohort Study, this database has addressed a number of key health issues pertaining to deploying UK military personnel, including a number of psychological health issues [26, 27] such as the prevalence of [24], risk factors for [28], and trajectories associated with PTSD [29], as well as other common mental disorders, alcohol misuse [24, 25, 30], and mTBI associated with deployments [31, 32]. In addition, Kings College London team also looked at whether there were any health symptoms which may be associated with receiving the anthrax vaccine [33].

While more than 300 publications have been generated which directly or indirectly address the aims of this program of research, recent publications demonstrate that approximately 17% of the respondents who have served in Iraq and Afghanistan meet the criteria for at least one psychological disorder and that in addition to combat and other traumatic deployment experience, the home environment also significantly impacts on the mental health of these personnel [34]. The research has also

published data that shows that individuals who deploy individually are no more likely to develop a psychological disorder including PTSD, in comparison to their counterparts who deploy as part unit, and in addition, were even found to be less likely to meet the criteria for alcohol misuse [35]. Nevertheless, perhaps one of the most important key finding that was recently published by the Kings College is in relation to delayed onset PTSD. This paper once again confirms the issue of delayed onset PTSD, and importantly highlights associations with prior psychological symptoms [29].

Once again, while extensive self report data was collected, objective measures of physical and psychological health were not included. In addition, biases may have been introduced as a consequence of the lead time between the baseline and follow-up survey, and while changes to health outcomes could be identified, it is unclear whether these are associated with deployment experiences or other factors.

2.1.3 Holland

A program of research has also been undertaken by the Dutch, who recruited participants for a prospective study which aims to investigate stress-related disorders following military deployment in the Dutch armed forces. Several papers have already been published including van Zuiden et al. [36], who found that pre-existing high glucocorticoid receptor numbers at pre-deployment predicted the onset of PTSD post-deployment. Data were collected from a sample of 34 military personnel with PTSD identified at 6 months post-deployment and compared with data from a control group of deployed soldiers without PTSD.

Using the same prospective study cohort, Geuze et al [37] collected data from 24 Dutch soldiers who were deployed for 4 months to Afghanistan, several weeks prior to deployment and again approximately 1.5 months post-deployment. At time point 1, participants completed a self report questionnaire assessing PTSD symptoms and exposure to prior trauma, glucocorticoid receptors and cortisol levels were assessed, body-mass index measured, and participants were asked to undertake a behaviour assessment during functional magnetic resonance imaging scanning (fMRI). This behaviour task together with fMRI was repeated at time point 2. This study found that pre-trauma glucocorticoid receptor numbers in peripheral blood mononuclear cells were negatively related to amygdala functioning.

Likewise, van Wingen et al. [38] evaluated the neural consequences of severe stress exposure. Data from a group of 33 healthy soldiers was compared with a group of 26 healthy soldiers not involved in combat missions. Both groups were tested at baseline (approximately 1.5 months after deployment for the combat group) and again approximately 6 months later. At both time points, a self report questionnaire evaluating PTSD symptoms, mood and anxiety levels, was completed. In addition, all participants undertook behavioural tasks with fMRI at both time points. Findings from this study demonstrate that prolonged exposures to trauma and stress, as is experienced within a combat environment, increases the amygdale insula reactivity to stimuli, resulting in sustained vigilance.

More recently van Wingen et al [39] recruited members from the same prospective study cohort to study the neural mechanisms underlying the long term effects of severe stress. Thirty three healthy deploying soldiers and 26 healthy controls who did not deploy, were recruited. In this study, data including a self report questionnaire measuring combat exposure and stress symptoms, a neuropsychological test of sustained attention, and a working memory task with fMRI were captured prior to deployment, 1.5 months and again 1.6 years after deployment for the combat group.

At approximately the same time, the same data were also captured for the control group.

One of the many strengths of van Wingen's study is the longitudinal follow-up at 1.6 years post-deployment. While this will be discussed in more detail later in this report, their 2012 study has highlighted the short term consequences of combat stress, the ability of some individuals to recover over-time, as well as the persistent changes that may increase an individual's vulnerability to future trauma [39]. However, the focus of these Dutch prospective studies is on the psychological and neurological consequences of deployment and therefore, unlike the MEAO Prospective Study, is limited as to the questions that can be addressed.

2.1.4 Germany

In order to investigate the prevalence, incidence and determinants of PTSD as well as other mental disorders in German troops who have served as part of the International Security Assistance Force mission to Afghanistan, a program of research including a cross-sectional and prospective study was commissioned [40]. The prospective component included 621 soldiers who completed a computer assisted military version of the Munich-Composite International Diagnostic Interview. This was supplemented with an interview and a self report questionnaire. This data was collected prior to deployment in 2011 and again approximately 12 months after returning from the mission. Post-deployment data collection, which is still ongoing, includes an autobiographical memory test, a cognitive flexibility test and an attention bias test. The participants are also being asked to provide a saliva and hair sample in order to measure cortisol levels.

2.2 The MEAO Prospective Study and Military Health Outcomes Program

The MEAO Prospective Study is the only longitudinal health study involving ADF members. It has collected both objective and self report data on a range of physical, psychological and social health outcomes. Together with the 2010 ADF Mental Health Prevalence and Wellbeing Study and the MEAO Census Study, the MEAO Prospective Study forms part of a series of health studies funded by Defence which are collectively referred to as the Military Health Outcomes Program (MilHOP). MilHOP was designed to add to the growing body of knowledge that has already been collected under the Deployment Health Surveillance Program.

In short, the MilHOP studies include:

- **MEAO Prospective Study is the subject of this report.** This longitudinal study, conducted by the Centre for Military and Veterans' Health at the University of Adelaide, collected data prior to and again post-deployment on members deploying to the MEAO after June 2010 and returning to Australia by June 2012. Details of the methodology are provided in Chapter Three. In addition to self report questionnaires, objective physical testing measures and neurocognitive assessments were also conducted on a sub-sample of deployed personnel at both time-points.
- The 2010 Mental Health Prevalence and Wellbeing Study conducted jointly by the Centre for Traumatic Stress Studies at the University of Adelaide and the Directorate of Strategic Operational Health in Joint Health Command, was a major deliverable of the ADF Mental Health Reform Program, measuring the

prevalence of psychological disorders in the entire ADF (deployed and non-deployed personnel).

- MEAO Census Study was conducted by the Centre for Military and Veterans' Health at the University of Queensland. This retrospective study collected self report data on a range of health outcomes and deployment experiences from ADF members who had deployed and returned from the MEAO before January 2011.
- MEAO Mortality and Cancer Incidence Study links records from Australian Institute of Health and Welfare databases in order to compare the death and cancer incidence rates for military personnel who have deployed to the MEAO with the general Australian population.

2.3 MEAO Prospective Study Questions

The MEAO Prospective Study has specifically been designed to answer a wide range of questions pertaining to the physical, psychological and social health of Australian military personnel deployed to the MEAO. While this unique database can assist to address many of the future health concerns associated with deployment, this report specifically addresses the following questions.

- 1. Are there changes in health outcomes between pre- and post-deployment in ADF personnel deploying to the MEAO?
- 2. What exposures and other risk factors are associated with changes in health outcomes?
- 3. What are the protective (resilience) factors for psychological health outcomes?
- 4. Are there any physical or psychological disorders or symptom clusters that are associated with particular features of deployment to the MEAO?
- 5. Are there relationships between deployment exposures and non-specific symptoms and specific health problems?
- 6. What is the trajectory and pattern of psychological morbidity and its somatic manifestations and antecedents?
- 7. What role do biological measures play as mediating variables between exposure and symptom formation?
- 8. Are there gender differences in any health impact of MEAO deployment?
- 9. What is the value of measures utilised in the study as screening tools and tests which may enable the early detection of disorders so as to instigate treatment earlier and minimise disability in veterans?
- 10. What role do these biological measures play as screens?
- 11. How can the utility of ADF health records for monitoring of the physical and psychological health of serving members be increased?

2.4 Summary

This is the first prospective study looking at the health of Australian military personnel. While a number of Australia's coalition partners have undertaken similar longitudinal health studies, they have faced a variety of challenges. These include the need to account for lag times between the deployment exposures and data

collection, the bias which is sometimes introduced with self-report data and a limitation on the range of health outcomes which were considered. The final two chapters of this Introductory Section will describe how the longitudinal design employed by the MEAO Prospective Study has overcome many of these issues. Details of the methods and measures used to capture the self-report and objective data in the MEAO Prospective Study are presented in Chapter Three. Following this, an overview of the response rates and primary characteristics of the MEAO Prospective Study sample are presented (Chapter Four).

Sections two to six of the report then present and discuss the primary findings of the MEAO Prospective Study, including:

- Psychological Health Outcomes in Section Two,
- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five

Finally, the conclusions and limitations of the study conclude the MEAO Prospective Study report in Chapter Twenty Two.

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Chapter Three – Design and Methods

Key Points

- 1. The MEAO Prospective Study was designed to investigate the health outcomes related to deployment in a war zone and incorporate the lessons highlighted by the Institute of Medicine.
- 2. This study was specifically designed to ensure that a wide range of objective markers as well as subjective reports on potential psychological, physical and social health impacts were captured.
- 3. All ADF members who deployed to the MEAO after June 2010 and returned from that deployment by June 2012 were eligible to participate in the self-report questionnaire component.
- 4. In addition, objective measures of health were also collected through physical tests and neurocognitive assessments in a sub sample of primarily combat personnel.
- 5. Detailed protocols and quality management plans ensured that the study was conducted in accordance with accepted best practice standards for research.

This chapter begins by outlining the longitudinal design of the MEAO Prospective Study before detailing the three components of the study, namely self-report data, physical tests and neurocognitive assessments. Details pertaining to recruitment, data security and confidentiality and statistical analysis are also included within this chapter.

3.1 Design

The MEAO Prospective Study was designed (see Table 3.1) to implement the lessons learnt from longitudinal studies which have already been conducted. In order to ensure that any changes in health outcomes could be directly attributable to the deployment experience rather than prior life exposures, data was collected immediately prior to (pre-deployment) and then again directly after (post-deployment) returning from deployment. In addition, rather than focusing on a small number of specific exposures, the MEAO Prospective Study was designed to measure a diverse range of health issues relevant to deployed military populations. The MEAO Prospective Study was also specifically designed to collect objective measures of health through physical tests and neurocognitive assessments conducted at both pre- and post-deployment, rather than relying solely on self-reported symptoms. Together this design ensured that a wide range of objective markers as well as subjective measures of psychological, physical and social impacts, which may be related to deployment were captured.

Table 3.1: Outline of the MEAO Prospective Study

The prospective study design was used to collect self-reported data from a sample of ADF members who **deployed to the MEAO after June 2010 and returned from that deployment by June 2012**. In addition, a sub-sample of primarily combat personnel was also invited to provide objective health measures – namely physical tests and/or neurocognitive assessments.

All data were collected at two time points: **Pre-Deployment** - Not more than four months prior to deploying. **Post Deployment** – On average 4.2 months after returning home from deployment.

There were three components to the study.

- Self-Report Questionnaire
- Physical Test
- Neurocognitive Assessment

3.1.1 Development of Methodology

Development of the MEAO Prospective Study methodology was initially informed by the 2007 Review of the Scientific Literature Relevant to Research into Health Effects of Veterans of the MEAO [1], and recommendations from the 2008 Institute of Medicine expert panel report which found several distinct categories of health outcomes demanding further research [2] (Table 3.2).

Table 3.2: Excerpt from summary of Institute of Medicine findings regarding the associationsbetween deployment to a war zone and specific health and psychosocial effects [2]

Sufficient Evidence of an Association

- Psychiatric disorders, including PTSD, other anxiety disorders, and depressive disorders*
- Alcohol use*
- Accidental death in the early years after deployment
- Suicide in the early years after deployment
- Marital and family conflict*

Limited but Suggestive Evidence of an Association

- Illicit drug use
- Chronic fatigue syndrome*
- Gastrointestinal symptoms consistent with functional gastrointestinal disorders, such as irritable bowel syndrome or functional dyspepsia*
- Skin disorders*
- Fibromyalgia and chronic widespread pain*
- Increased symptom reporting, unexplained illness, and chronic pain*
- Incarceration

Inadequate /Insufficient Evidence to Determine Whether an Association Evists
a Cancar
Diabetes mellitus
Thyroid disease
 Neurocognitive and neurobehavioral effects*
 Sleep disorders or objective measures of sleep disturbance*
Hypertension*
Coronary heart disease
Chronic respiratory effects*
 Structural gastrointestinal diseases
Reproductive effects
Homelessness
Adverse employment outcomes

* Disorders addressed by the MEAO Prospective Study

In addition, a **MEAO Preliminary Study** was conducted in 2009 in order to obtain broad stakeholder and consumer input into data collection and recruitment strategies. Feedback from 28 focus groups involving 143 ADF serving, ex-serving, regular and reserve members who had deployed to Iraq and/or Afghanistan was used to refine the data collection tools. A draft questionnaire was then pilot-tested by volunteers who had participated in the original focus groups. This preliminary work has been fully described in the MEAO Preliminary Study Report and Detailed Research Plan (Appendices A and B).

Finally, a **MEAO Prospective Pilot Study** was conducted in March 2010 to test the methods for collecting questionnaire and physical testing data. 25 Aircrew from RAAF Base Edinburgh who had previously deployed to the MEAO, were invited to participate in this pilot test. Lessons learned, including the importance of briefing senior officers to ensure their support, were used to further improve the self report questionnaire, physical testing and neurocognitive assessment data collection processes.

3.2 Measures

The MEAO Prospective Study collected three distinct types of data at both pre- and post-deployment. While the questionnaire component was designed to collect self-reported information pertaining to psychological and physical symptoms, as well as deployment-related exposures and other life experiences, the physical tests and neurocognitive assessments ensured that objective measures of health were also captured. Detailed protocols and quality management plans were developed for each component of the study to ensure that data were collected, assessed and managed in accordance with research best practice (see Appendices C, D and E).

3.2.1 Self Report Questionnaire

The self-report questionnaire component was designed to collect measures on psychological, physical and social health at both pre- and post-deployment; exposures and life experiences prior to deploying and exposures while on and immediately after deployment. A summary of the items included in both the pre- and post-deployment self-report questionnaire is provided in Table 3.3, while a more detailed description is provided in Appendix F.

Table 3.3: Overview of measures included in the self-report questionnaire

Pre-Deployment Self-Report Questionnaire

The broad categories of questions that were covered in the pre-deployment self report questionnaire administered at time point one were:

- **Brief Deployment History** Participants were asked about their deployments country deployed to, operation name, year deployment started, number of times deployed in that year, and the total time deployed (in months).
- **Pre-Deployment Health** This part of the questionnaire was designed to elicit information about the participants' mental health, physical health, social function and health risk factors, prior to deployment. Topics were identified by the review of literature, consultation with stakeholders and focus groups with serving and ex-serving personnel. Items and scales were obtained from a number of different sources.
- Personality and Resilience This section of the Pre-Deployment questionnaire aimed at identifying individual factors such as personality traits and preferences, as well as other life experiences which could contribute to particular health outcomes.

Post-Deployment Self-Report Questionnaire

The broad categories of questions that were covered in the post-deployment self report questionnaire administered at time point two were:

- **Post-deployment Health** This part of the questionnaire was designed to elicit information about the participants; mental health, physical health, social function and health risk factors, since the beginning of their most recent deployment. In order to identify changes in health outcomes since the beginning of their most recent deployment, apart from the time period, the questions were the identical to those used in the Pre-Deployment Health section above.
- **Deployment Experiences** This section was used to identify health hazards and threats both real and perceived, in relation to the most recent deployment to the MEAO. Questionnaire items were identified by the review of the literature and review of Hazard Assessment Team reports. In addition, hazards reported by serving and ex-serving personnel during the preliminary study focus groups were incorporated.

3.2.1.1 Self Report Questionnaire Quality Assurance

The detailed Questionnaire Protocol can be found in Appendix C. The quality management plan, included within this protocol, details how the questionnaire data was audited on a quarterly basis.

3.2.1.2 Sections of the Report Relevant to the Questionnaire

Analyses of the questionnaire data are presented throughout the report. However, Section Two specifically focuses on findings pertaining to psychological health utilising many of the measures included within both the pre- and post-deployment questionnaire and Section Three of this report focuses on analyses of the somatic symptoms and mTBI data which was also included within the pre- and post-deployment questionnaire.

3.2.2 Physical Testing Measures

The physical testing component was designed to capture objective measures of health outcomes at both pre- and post-deployment. They included:

- Height, weight, waist and hip circumference
- Systolic and diastolic blood pressure
- Lung function (spirometry) including peak flow and tidal volume
- Cardiovascular fitness (Queens College Step Test)

Photographs of a participant's palms of their hands, soles of their feet, back and the cheek section of their face were also taken in order to identify any dermatological changes between pre- and post-deployment.

A 40ml blood sample was also collected in order to measure chronic infections, markers of inflammation and biochemistry (Table 3.4) at both pre- and post-deployment (see Appendix G for assay details).

Pathology Tests Undertaken	Related Chapters in this Report
Lipids - High Density Lipoprotein Cholesterol, Low Density Lipoprotein Cholesterol, Total Cholesterol and Triglycerides	Chapter 16 – Biochemistry Chapter 21 – Allostatic Load
Enzymes - Gamma-glutamyl Transferase, Alanine Transaminase, Aspartate Transaminase, Creatine Kinase, Alkaline Phosphatase, Amylase and Lipase	Chapter 16 – Biochemistry Chapter 21 – Allostatic Load
Glucose Metabolics – Glucose and Glycated Haemoglobin	Chapter 16 – Biochemistry Chapter 21 – Allostatic Load
Inflammatory Mediators - C-Reactive Protein, Albumin, Tumor Necrosis Factor Alpha, Red Blood Cell Cholinesterase (also a marker of organophosphate exposure), Interleukin 6, Interleukin 4 and Interleukin 1	Chapter 21 – Allostatic Load
Nutritional State - Vitamin B12 and Folate	Chapter 16 - Biochemistry
Haematological Profile – Haemoglobin, Red Blood Cell Count, Packed Cell Volume, Mean Corpuscular Volume, Mean Corpuscular Haemoglobin, Mean Corpuscular Haemoglobin Concentration, Red Cell Distribution Width, Total White Cell Count and White Cell Differentiation Counts	Chapter 16 - Biochemistry
Electrolytes – Sodium, Potassium, Chlorine, Bicarbonate, Anion Gap, Urea and Urate	Chapter 16 - Biochemistry

Table 3.4: Pathology Tests Undertaken at Both Pre- and Post-Deployment

Infections – Helicobacter, Cytomegalovirus, Hepatitis C, Herpes Simplex Types 1, 2 and 1 &2, Mycoplasma Antibodies, Leishmania, Epstein Barr Virus, Chlamydophila Pneumoniae and Chlamydia	Chapter 15 - Infections
Renal Function - Creatinine Clearance and Homocysteine	Chapter 16 - Biochemistry

3.2.2.1 Physical Testing Quality Assurance

All physical tests were conducted by professional health staff from Healthscope who had received specific training in the Physical Testing Protocol (Appendix D). Pathology testing was conducted at the same selected laboratories at both pre- and post-deployment.

Pathology reports were reviewed by the study medical practitioner Dr Keith Horsley, University of Adelaide and a medical advisor to Medibank Solutions. Photographs were analysed by Dr Jennifer Menz, Head of Dermatology at the Repatriation General Hospital and spirometry data were analysed by Associate Professor Alan Crockett who currently holds the position of Professor of Clinical Respiratory Physiology at the University of South Australia.

3.2.2.2 Sections of the Report Relevant to the Physical Testing

Analyses of the physical testing data including height, weight, waist and hip circumference, blood pressure, lung function and active and resting heart rate is presented in Section Three of this report, while analyses of biomedical markers forms the basis of Section Four. In addition, physical testing data also formed the basis of the Allostatic Load measures presented in Chapter 21.

3.2.3 Neurocognitive Assessments

The MEAO Prospective Study used the Brain Resources LabNeuro platform to conduct a battery of psychophysiology assessments to investigate the relationships between factors which may impact on memory and concentration in deployed personnel and are critical to capability and performance. Five paradigms were utilised during these assessments to optimally cover as broad a range of activity as possible in a one-hour measurement period (see Table 3.5). However, only two of the paradigms, qEEG and Working Memory are included within this report.

Table 3.5: Neurocognitive Assessments Undertaken at Both Pre- and Post-Deployment

Quantitative electroencephalography (qEEG) allows the measurement of cortical arousal in the resting state, which reflects the priming of the individual to deal with environmental challenge.

The Working Memory Task taps into a domain of function that is known to be abnormal in chronic mTBI and psychiatric disorders and allows the measurement of reaction times.

The Startle Response Task involves a measure of arousal modulation and orientation to the environment that is known to change in PTSD. It is also a symptomatic marker whose objective measurement may have the capacity to be used as a screen of psychological symptoms independent of self report.

The Emotion Processing Task - important significant differences have been found in the processing of facial emotion in individuals with posttraumatic stress disorder. As well, the processing of unconscious facial expression provides particular information about the fear networks in the brain.

The Response Inhibition Task provides a measure of the capacity of the individual to suppress a natural tendency to respond. This captures frontal inhibition of response by using both speed and accuracy of responses as well as the ability to inhibit inappropriate automatic responses.

3.2.3.1 Neurocognitive Assessment Quality Assurance

The detailed neurocognitive protocol can be found in Appendix E. All neurocognitive assessments were conducted by research officers from the University of Adelaide who had trained and successfully passed assessment as competent neurocognitive acquirers by Brain Resources. Once collected, the electronic data was downloaded to Brain Resources who then cleaned and scored the data in preparation for analysis.

3.2.3.2 Sections of the Report Relevant to the Neurocognitive Assessment A detailed analysis of two of the neurocognitive assessments (qEEG and working memory) can be found in Section Five of this report.

3.2.4 Exceptions to Data Collection

Table 3.6 identifies a number of exceptions that were made to the original data collection protocols.

Table 3.6: Exceptions to data collection

Saliva Samples - An attempt was made to collect an evening and morning saliva sample in order to measure cortisol, adrenalin and noradrenalin levels. Attempts to obtain a saliva sample were, however, abandoned during post-deployment data collection due to low pre-deployment response rates (26.6% of physical testing pre-deployment responders), which meant that this data collection was not cost effective. One possible reason for the low response rate was the additional requirement for the participant to abstain from alcohol prior to collecting an evening and morning sample, and then returning these samples to base the following day. Due to the low response rate the Investigator Committee decided to cease collection and not report on cortisol, adrenalin and noradrenalin levels. All collected saliva samples were destroyed on the 10th January 2012.

Skin Photography - Pre- and post-deployment photography was not collected for the final Mentoring Task Force unit due to concern with the time taken to complete this part of the physical testing data collection. In cases where participants had already participated in pre-deployment skin photography, the Investigator Committee agreed that post-deployment skin photography should be collected and included in the data analysis.

Lead Levels – An analysis of lead levels was discontinued after pre-deployment as it was believed that exposure to high levels of lead while on deployment were unlikely.

3.3 Ethics committee approvals

The MEAO Prospective Study methodology was approved by the Australian Defence Human Research Ethics Committee (ADHREC) (Protocol no. 488-07), and the University of Adelaide Human Research Ethics Committee (UA HREC) (Protocol no. H-064-2008).

3.4 Recruitment

Thirteen units and a ship, who met the eligibility criteria were identified and agreed to participate. In addition data was collected from a number of military personnel who did not deploy as part of a unit. Despite extensive efforts, the MEAO Prospective Study was not able to gain access to all units who deployed to the MEAO after June 2010 and returned from that deployment by June 2012. Some of the units were unavailable because of their extensive pre-deployment activities, and/or the study team was not provided with sufficient information to ensure that face to face data collection could be arranged prior to the deployment date.

3.4.1 Study population

The study was provided access to the following deploying units.

- **1 x Navy Ship** (HMAS Stuart) which was responsible for conducting maritime security operations across the Combined Maritime Forces' area of operations.
- **2 x Army Mentoring Task Force Units (MTF2 and MTF3)** whose members were drawn predominately from 2RAR and 3RAR respectively, were responsible for mentoring and security operations in Uruzgan province.
- **1 x Force Communications Unit (1FCU)** which was responsible for the provision of national command and welfare communications and information systems to the Joint Task Force, supporting National Command and Control across the MEAO.
- **2 x Force Support Units (1FSU and 2FSU)** which was responsible for providing logistic support, camp maintenance and theatre induction training in the MEAO.
- 2 x Special Operations Task Group (SOTG). The SOTG trains, mentors and partners with Afghan National Police officers from the Uruzgan Provincial Response Company (PRC) and other branches of the Afghan National Security Forces, in order to build their capacity and capability to establish and maintain security and stability in the region. The members were drawn predominately from SASR, SOER, 1 CDO and 2 CDO.

- 2 x Airforce Combat Support Units (1CSU and 2CSU) which were responsible for managing the administrative and support functions at AI Minhad Air Base.
- 1 x Airforce C130 Unit (C130s)
- 1 x Airforce 92Wing (Orion P3s)
- A variety of members deployed from 39PSB (39PSB)
- A variety of members deployed from Multi-Task Group (TK)
- A variety of members deployed with **Coalition units**.

All members from these units that were about to deploy to the MEAO were invited to participate in the questionnaire component of the study. Members of the two Mentoring Task Force Units and the SOTG were also invited to participate in physical testing and neurocognitive assessment components of the Study. In addition, crew from the ship were invited to participate in the physical testing component.

3.4.2 Questionnaire eligibility criteria

In order to be eligible to participate in the MEAO Prospective Study questionnaire component, individuals must have been members of the ADF and deploying to the MEAO after the June 2010, and returning to Australia from deployment by June 2012.

These inclusion criteria applied regardless of:

- Service (Navy, Army or Air Force);
- Rank;
- Gender;
- the length of deployment;
- the country where most time would be spent (i.e. the person could have been in Afghanistan or in an area/country (outside Australia) supporting these operations);
- the role (combat, support, technical etc); and/or
- whether the ADF member had previously deployed to the MEAO.

Exclusion criteria

The following criteria excluded individuals from being invited to participate in the Self-Administered Questionnaire. Individuals who are NOT members of the Australian Defence Force including:

- Members of foreign militaries seconded to the ADF;
- Civilian contractors (whether bound to Defence Force Discipline Act or not);
- Government officials (e.g. Department of Foreign Affairs and Trade (DFAT);
- Aid workers (including Australian Government officials);
- Civilians contracted to Defence Science Technology Organisation (DSTO);
- Public Servants;
- Australian Federal Police; and
- ADF personnel accompanying government officials or representatives not technically required for conduct of operations.

Table 3.7 presents the total population who met the self-report questionnaire criteria.

Characteristics	Sub groups	Population N	
Total Sample		3074	
Gender	Female	250	
	Male	2824	
Age	16-24	1076	
	25-34	1270	
	35-44	543	
	45-54	160	
	55 and over	23	
	Missing Age	2	
Service	Navy	233	
	Army	2289	
	Air Force	552	
Rank	Officer	467	
	NCO	1212	
	Other ranks	1395	
Duty	Regular	1762	
	Reservist	118	
	Missing Duty	1194	

Table 3.7: Population for self-report questionnaire data collection

3.4.3 Physical testing eligibility criteria

To be invited to participate in the physical testing, individuals must have been eligible to participate in the questionnaire component (see section 3.4.2 above), and be assigned to **one of the following**:

- the Navy ship
- either of the two Special Forces Commando Units (1CDR and 2CDR)
- either of the two Special Forces Special Air Services (SAS) Units (1SAS and 2SAS)
- either of the two Army Mentoring Task Force Units (MTF2 and MTF3)
- either of the two Army Force Communications Unit (1FCU)

There were no exclusion criteria applicable to the physical testing. Table 3.8 presents the total population who met the physical testing criteria.

Characteristics	Sub groups	Population N
Total Sample		655
Gender	Female	12
	Male	643
Age	16-24	277
	25-34	286
	35-44	77
	45-54	15
Service	Navy	33
	Army	619
	Air Force	3
Rank	Officer	49
	NCO	228
	Other ranks	378
Duty	Regular	589
	Reservist	36
	Missing Duty	30

Table 3.8: Population for physical test data collection

3.4.4 Neurocognitive eligibility criteria

To be eligible to participate in the neurocognitive assessments, individuals must have been eligible to participate in the questionnaire component (see section 3.4.2 above) and be assigned to **one of the following**:

- either of the two Special Forces Commando Units (1CDR and 2CDR)
- either of the two Special Forces Special Air Services (SAS) Units (1SAS and 2SAS)
- either of the two Army Mentoring Task Force Units (MTF2 and MTF3)
- either of the two Army Force Communications Unit (1FCU)

There were no exclusion criteria applicable to the neurocognitive assessments. Table 3.9 presents the total population who met the neurocognitive assessment criteria.

Characteristics	Sub groups	Population N
Total		278
Sex	Male	272
	Female	6
Age	16-24	87
	25-34	132
	35-44	44
	45-55	7
	Army	276
	Air Force	2

Table 3.9	Population	for neurocognitive	assessment dat	a collection
Table J.J.	ropulation	ior neurocoginuve	assessment uat	aconection

Rank	Officer	23
	NCO	106
	Other Ranks	149

3.4.5 Recruitment Strategies

Pre-deployment recruitment for all three types of data (questionnaire, physical testing and neurocognitive assessments) was conducted via face to face briefings. Commanding Officers and Officers Commanding were contacted by a Defence Liaison Officer and provided with a full brief on the Study. They and/or their designated point of contact were also given an opportunity to meet with members of the Research Team in order to obtain more detailed information about the study and the specific study outcomes that could directly assist in managing their unit. A suitable schedule for data collection was then developed.

To begin pre-deployment data collection, eligible participants were asked to attend an initial briefing which provided information about the purpose of the study. ADF members were then handed a briefing pack which contained all of the study information, together with a copy of the questionnaire (Appendix C). In many cases, time was available at the end of each briefing to complete the questionnaire. Alternatively, participants were provided with a reply paid envelope which allowed them to complete the questionnaire at a later date. At the same time, physical testing and neurocognitive assessment appointments were made for eligible participants who had agreed to participate in these components of the MEAO Prospective Study.

A mixture of methods was used to recruit participants at post-deployment. For units eligible for post-deployment physical tests and/or neurocognitive assessments, face to face data collection methods, similar to the pre-deployment strategies were utilised. In the case of units only eligible for the post-deployment questionnaire, participants were sent a hardcopy information pack (Appendix C) to their Defence address. At the same time they received an email containing a link to the same information and questionnaire online. One week after receiving the online link, participants who had not already responded received a reminder email. Follow up phone calls, if required, commenced two weeks after receiving the online link.

3.5 Data confidentiality and storage

The Data Management and Analysis Centre, University of Adelaide, was commissioned to develop the Defence Health Research System (DHRS). The DHRS has been accredited to RESTRICTED security level by Information Assurance, Department of Defence. In addition to a management information system which tracks participant response information, the primary purpose of the DHRS was to receive, store and manage all MEAO Health Study data. Electronic data from the questionnaire, physical testing and neurocognitive assessment were imported into the DHRS.

Hardcopy data including pathology results, letters to participants and paper copies of questionnaires are stored at facility within the Centre for Military and Veterans Health, University of Adelaide, which has also been accredited to a restricted status.

3.6 Duty of Care

To ensure that any participant deemed to be potentially at risk was contacted and provided with appropriate advice and support, the following detailed duty of care protocols were established for the following:

- Suicide Ideation (Appendix H)
- Abnormal Pathology Reports (Appendix I)
- Abnormal Dermatological Report (Appendix J)
- Abnormal Lung Function (Appendix K)

3.7 Statistical Analyses

In order to answer the questions of interest to the MEAO Prospective Study, a number of analytical methods were employed. Analyses were conducted in SAS version 9.3. For each outcome variable the effect size is estimated with 95% confidence limits. Statistical significance is assessed at $p \le 0.05$ level.

For continuous outcomes, descriptive statistics (including mean and confidence intervals), along with graphical displays (histograms) where appropriate, are presented.

Mixed models for repeated measures were used for continuous outcomes, such as those for respiratory health. This approach allows for the use of repeated measures on the same individual (i.e. pre- and post-deployment) in order to investigate changes in health outcomes over time. For each association, the changes in health outcomes were compared between the groups. Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post-deployment) and their interaction(s) are included as fixed effects in the model.

A logistic regression model was used for dichotomous outcomes, such as mTBI (present, absent) the number and percentage of participants experiencing the outcome of interest is shown.

For categorical outcomes, such as the severity bands for K10, PCL-C, AUDIT, PHQ-9, step-wise change across bands (1 step, 2 steps) between pre- and postdeployment was calculated for each participant. These changes were then simplified into three change categories ('Increase', 'Decrease' or 'No change'). These were then used as a three level categorical outcome in a multinomial logit model. This approach allowed for the shift in severity of symptoms between the two time points to be examined. In all models the default reference category was 'no change'. Where a different reference category was used, this is stated in the text.

As suggested by the literature, a number of demographic factors can impact on outcomes. Therefore, all models were adjusted for gender (Male, Female), service (Army, Navy, Air Force), rank (commissioned officer, non-commissioned officer, other ranks), and age (in years), unless otherwise stated.

3.8 Interpreting the analyses

The main aim of the statistical analyses was to test the difference in health outcomes between pre- and post-deployment for particular groups of interest. For example, the analyses considered whether change in health outcomes between pre- and postdeployment was different for those who were, compared to those who were not exposed to combat while on deployment.

For all models, **the p-value** is calculated to show whether the difference may have occurred by chance. The p-value is the probability that effects as big as, or bigger than those seen in the study would be observed if there was really no difference between the groups. Conventionally, a p-value less than 0.05 is interpreted to mean that the difference seen probably did not occur due to chance (i.e. it probably does reflect a true difference between the groups being examined). Thus a p-value less than 0.05 is commonly described as indicating that the results are 'statistically significant'.

For continuous outcomes, the mean for each group and the associated 95% confidence interval are presented. **Confidence intervals** show the range of values within which the true result probably lies. More correctly, if we repeated our study 100 times (with 100 different samples) and calculated a confidence interval each time, in 95 of those studies the confidence interval would contain the "true" value.

For dichotomous, nominal and ordinal outcomes, prevalence **odds ratios** and their confidence intervals are presented. The prevalence odds ratio is the odds of exposure in persons with the particular symptom or health outcome divided by the odds of exposure in persons who do not have that symptom or health outcome. The odds of exposure in one group is the number of persons in the group (e.g. the group with the symptoms) who were exposed divided by the number of persons in that group who were not exposed. An odds ratio may range in value from zero to infinity. An odds ratio that is larger than one occurs when there is a positive association between exposure (e.g. exposure to combat) and the symptom or health outcome. An odds ratio that is less than one has the reverse interpretation, and an odds ratio equalling one would indicate that those exposed to combat and those that were not had the same association with the outcome of interest.

3.9 Summary

The MEAO Prospective Study was specifically designed to ensure that a wide range of objective markers as well as subjective reports on potential psychological, physical and social health impacts were captured. All ADF members who deployed to the MEAO after June 2010 and returned from that deployment by June 2012 were eligible to participate in the self-report questionnaire component. In addition, objective measures of health were also collected through physical tests and neurocognitive assessments in a sub sample of primarily combat personnel. Data were collected at two time points – immediately prior to deployment (pre-deployment) and then again not more than four months after returning to Australia (post-deployment).

Detailed protocols were developed for each component of the study which not only ensured the quality and security of the data, but also respect and care for the participants. In addition, the MEAO Prospective Study developed a complex analysis plan in order to identify changes in health outcomes associated with the most recent deployment, any exposures, risks or resilience factors which may be associated with those changes and the specific trajectories of psychological health for this particular cohort. The next chapter completes the Introductory Section by presenting the proportions of population who completed both the pre- and post-deployment self-report questionnaire, physical test and/or neurocognitive assessments, and the proportion of the population who only completed these components of the study at pre-deployment. In addition, detailed characteristics for respondents who completed both the pre- and post-deployment components are provided.

Sections two to six of the report then present and discuss the primary findings of the MEAO Prospective Study, including:

- Psychological Health Outcomes in Section Two,
- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five

Finally, the conclusions and limitations of the study conclude the MEAO Prospective Study report in Chapter Twenty Two.

3.10 References

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Chapter Four – Response Rates and Sample Characteristics

Key Points

- 1. Of the total population (n=3074), 60.9% responded to the pre-deployment self-report questionnaire and 70.8% of those also completed a further self report-questionnaire at post-deployment.
- 2. A total of 655 also participated in a physical test at pre-deployment, and 60.9% of those respondents also undertook the same physical test at post-deployment. The majority of respondents who completed both a pre- and post-deployment physical tests were male and in the Army.
- 3. A total of 278 also participated in a neurocognitive assessment at predeployment, and 61.2% of those respondents also undertook the same neurocognitive assessment at post-deployment. The majority of respondents who completed both a pre- and post-deployment neurocognitive assessment were male and in the Army.

This chapter presents the response rates for each of the three components of the MEAO Prospective Study. The chapter also compares basic characteristics of the two responder groups – those that completed both pre- and post-deployment and those who only responded at pre-deployment, in order to identify whether there are any differences between the two groups. In addition, this chapter also provides detailed deployment related characteristics for those respondents who participated in both a pre- and post-deployment component of the study.

4.1 Response Rates

The MEAO Prospective Study invited all ADF members who **deployed to the MEAO after June 2010 and returned from that deployment by June 2012** to complete a self report questionnaire. In addition, a sub sample of combat personnel was also invited to participate in a physical test and/or neurocognitive assessments. For each of these components there are two distinct groups of responders – those who completed both the pre- and post-deployment data collection and those that completed only responded at pre-deployment. In addition to providing the characteristics of the total population, the characteristics of both of these responder groups are also provided in the following sections.

4.1.2 Questionnaire Response Rates

Table 4.1 shows the total eligible population and the response rate for the participants who completed just the pre-deployment questionnaire, compared to the participants who completed both the pre- and post-deployment questionnaires.

Characteristic		Population (N)	Pre- Only N (%)	Pre- and Post- Deployment N (%)	Non Responders N (%)
Total		3074	547 (17.8%)	1324 (43.1%)	1203 (39.1%)
Sex	Male	2824	502 (17.8%)	1197 (42.4%)	1125 (39.8%)
	Female	250	45 (18.0%)	127 (50.8%)	78 (31.2%)
Age	16-24	1076	203 (18.9%)	397 (36.9%)	476 (44.2%)
	25-34	1270	257 (20.2%)	528 (41.6%)	485 (38.2%)
	35-44	543	76 (14.0%)	272 (50.1%)	195 (35.9%)
	45-55	160	11 (6.9%)	108 (67.5%)	41 (25.6%)
	55+	23	0 (0.0%)	19 (82.6%)	4 (17.4%)
	Missing	2	0 (0.0%)	0 (0.0%)	2 (100.0%)
Service	Navy	233	32 (13.7%)	69 (29.6%)	132 (56.7%)
	Army	2289	397 (17.3%)	925 (40.5%)	967 (42.2%)
Air Force		552	118 (21.4%)	330 (59.8%)	104 (18.8%)
Rank	Officer	467	66 (14.1%)	245 (52.5%)	156 (33.4%)
	NCO	1212	218 (18.0%)	523 (43.2%)	471 (38.8%)
	Other Ranks	her Ranks 1395		556 (39.9%)	576 (41.2%)

Table 4.1: Response rates for questionnaire. Note: Age is calculated as at pre-deployment.

As the self-report questionnaire was particularly long an analysis was conducted to identify if responders did not complete the survey. The analysis found that for those who only participated at pre-deployment, 92% (n=503) had answered the final question of the survey. For respondents that participated in both pre- and post-deployment data collection, 91% (n=1206) were found to have answered the last question for both the pre- and post-deployment self-report questionnaires. While responders may not have answered every question, this analysis does suggest that the majority of the responders were likely to have completed a significant proportion of the self-report questionnaire/s.

4.1.3 Physical testing response rate

Table 4.2 shows the response rate for the participants who completed just the predeployment questionnaire, compared to the participants who completed both the preand post-deployment questionnaires.

Characteristic		Population (N)	Pre- Only N (%)	Pre- and Post-Deployment N (%)
Total		655	256 (39.1%)	399 (60.9%)
Sex	Female	12	7 (58.3%)	5 (41.7%)
	Male	643	249 (38.7%)	394 (61.3%)
Age	16-24	277	89 (32.1%)	188 (67.9%)
	25-34	286	132 (46.2%)	154 (53.8%)
	35-44	77	30 (39.0%)	47 (61.0%)
	45-55	15	5 (33.3%)	10 (66.7%)
Service	Navy	33	15 (45.5%)	18 (54.5%)
	Army	619	238 (38.4%)	381 (61.6%)
	Air Force	3	3 (100.0%)	-
Rank	Officer	49	30 (61.2%)	19 (38.8%)
	NCO	228	99 (43.4%)	129 (56.6%)
	Other Ranks	378	127 (33.6%)	251 (66.4%)

Table 4.2: Response rates for physical testing. Note: Age is calculated as at pre-deployment

The physical test had a number of sections and not all respondents completed each section. Table 4.3 compares the number of sections completed in the pre-deployment physical test, for those that completed only the pre-deployment physical test and those that completed both the post-deployment physical test.

Physical Test Component	Pre-Deployment Only N (%)	Post-Deployment N (%)
Height and Weight	255 (38.9%)	399 (60.9%)
Waist and Hip Ratio	256 (39.1%)	392 (59.8%)
Systolic and Diastolic Blood	256 (39.1%)	398 (60.8%)
Pressure		
Lung Function (Spirometry)	246 (37.6%)	391 (59.7%)
Cardiovascular Fitness (Queens	244 (37.3%)	381 (58.2%)
College Step Test)		
Skin Photography	87 (13.3%)	140 (21.4%)
Blood Tests	228 (34.8%)	372 (56.8%)

Table 4.3: Pre-deployment physical test progress by pre- only in comparison to pre- and postdeployment responders

In comparison, Table 4.4 presents the number and percentage of this sample who completed each section of the physical test data collection at both pre- and post-deployment. Numbers vary from the above table may have attended the physical testing data collection at both pre- and post-deployment but chosen to opt out of any of the tests at either time point.

Table 4.4: Post-deployment physical test progress for pre- and post-deployment responders	Table 4.4	: Post-deploy	ment physical	test progress	for pre- and	post-deployment	responders
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Physical Test Component	Pre- and Post- Deployment N (%)
Height and Weight	399 (60.9%)
Waist and Hip Ratio	397 (60.6%)
Systolic and Diastolic Blood Pressure	396 (60.5%)
Lung Function (Spirometry)	383 (58.5%)
Cardiovascular Fitness (Queens College Step Test)	363 (55.4%)
Skin Photography	138 (21.1%)
Blood Tests	357 (54.5%)

4.1.4 Neurocognitive response rate

Table 4.5 shows the response rate for the participants who completed just the predeployment neurocognitive assessment, compared to the participants who completed both the pre- and post-deployment neurocognitive assessment data analyses.

Characteristic		Population (N)	Pre- Only N (%)	Pre- and Post- Deployment N (%)
Total		278	108 (38.8%)	170 (61.2%)
Sex	Male	272	108 (39.7%)	164 (60.3%)
	Female	6	-	6 (100%)
Age	16-24	87	35 (40.2%)	58 (66.7%)
	25-34	132	57 (43.2%)	77 (58.3%)
	35-44	44	15 (34.1%)	29 (65.9%)
	45-55	7	1 (14.3%)	6 (85.7%)
	Army	276	106 (38.4%)	170 (61.6%)
	Air Force	2	2 (100%)	-
Rank	Officer	23	14 (60.9%)	9 (39.1%)
	NCO	106	38 (35.8%)	68 (64.2%)
	Other Ranks	149	56 (37.6%)	93 (62.4%)

 Table 4.5: Response rates for physical testing. Note: Age is calculated as at pre-deployment

As presented in Table 4.5, 61.2% of the total population available for neurocognitive assessments at pre-deployment also completed the assessments at post-deployment. The primary reasons for pre-deployment participants not completing the post-deployment assessment was that they had been posted to another region immediately after returning from deployment, they had discharged immediately after returning from deployment, their military duties did not allow them to participate within the timeframe allowed for assessments.

4.2 Characteristics of Pre- and Post-Deployment Responders

As the primary research questions pertain to changes in health outcome between pre- and post-deployment, the primary analysis presented in each of the following chapters only included those responders who have completed both the pre- and post-deployment component. This section of the chapter presents additional deployment related characteristics of those participants who responded at both preand post-deployment.

4.2.1 Number of Prior Deployments

The number of prior deployments (including war like deployments, peacekeeping missions and border patrols) was captured in the self-report questionnaire. The number ranged from 0 to 78 and the mean number of prior deployments for the preand post-deployment sample was 2.2 times.

For the purposes of analyses, the number of prior deployments was categorised into the following groups:

- No prior deployments
- 1 2 prior deployments
- 3 4 prior deployments
- 5+ prior deployments

Table 4.6 shows the number of prior deployments for participants who completed both the pre- and post-deployment self report questionnaire.

Number of prior deployments	Number (%) respondents
No prior deployments	432 (32.6%)
1 – 2 prior deployments	434 (32.8%)
3 – 4 deployments	165 (12.5%)
5+ prior deployments	164 (12.4%)
Missing	129 (9.7%)

Table 4.6: No. of deployments for the pre- post- respondents

As presented in Table 4.6, the 67.4% (n=892) of the MEAO Prospective Study sample had been on at least one prior deployment.

4.2.2 Number of Months Deployed in the Previous Three Years

The time spent on prior deployments (including war like deployments, peacekeeping missions and border patrols) in the previous three years. This score, which ranged from 0 to 20 was categorised into the following groups:

- None
- 1-6 months
- 7-12 months
- > 12 months

Table 4.7 shows the time away on previous deployment for participants who completed both the pre- and post-deployment self report questionnaire.

Table 4.7: No. of months deployed in previous 3 years for the pre- post- respondents

Number of months deployed last 3 years	Number (%) respondents
None	432 (32.6%)
1-6 Months	230 (17.4%)
7-12 months	257 (19.4%)
>12 months	59 (4.5%)
Missing	346 (26.1%)

4.2.3 Length of Most Recent Deployment

Length of most recent deployment was provided by the ADF and categorised, using quartiles, into the following groups:

- ≤ 5 months
- 6 or 7 months
- 8 months
- 9 12 months

Table 4.8 shows the length of most recent deployment for participants that completed both the pre- and post-deployment self report questionnaire.

Table 4.8: length of most recent deployment for the pre- post- responders

Length of most recent deployment	Number (%) respondents
≤ 5 months	400 (30.2%)
6 or 7 months	404 (30.5%)
8 months	290 (21.9%)
9-12 months	230 (17.4%)

4.2.4 Role on Most Recent Deployment

The role on most recent deployment was captured in the self report post-deployment questionnaire. Roles were categorised into the following three groups with assistance from the ADF:

- Combat Afghanistan & Outside Main Support Base (MSB)
- Inside MSB
- Outside Afghanistan

Table 4.9 shows the role on most recent deployment for participants who completed both the pre- and post-deployment self report questionnaire.

Table 4.9: role on most recent deployment for the pre- post- responders

Role on deployment	Number (%) respondents
Combat Afghan & Outside MSB	686 (51.8%)
Inside MSB	299 (22.6%)
Outside Afghanistan	339 (25.6%)

4.2.5 Traumatic Deployment Experience Categories

The post-deployment self report questionnaire contained 26 questions about specific traumatic deployment related experiences (refer Appendix C). In order to assess the association between specific traumatic deployment experiences and changes in Kessler 10 (K10) mean scores between pre- and post-deployment, the 26 items were grouped into nine broad categories (Table 4.10) which were considered to be of a similar nature. These groupings were based on previous research on combat exposures by Wilk and colleagues [16] and were also used in the MEAO Census Study report.

 Table 4.10: Categories of Traumatic Deployment Exposures

Category	Items in the Survey	
Coming under fire	Came under small arms or anti-aircraft fire	
<u> </u>	Came under guided or directed mortar/artillery fire	
	Experienced indirect fire (e.g. rocket attack)	
	Experienced an IED/EOD that detonated	
	Experienced a suicide bombing	
	Experienced a landmine strike	
	Encountered small arms fire from an unknown enemy	
Discharging own weapon	Discharged your own weapon in direct combat	
Unable to respond to a threatening situation	Experienced a threatening situation where you were unable to respond due to the rules of engagement	
Vulnerable situations or fear	Seriously feared you would encounter an IED	
of events	Went on combat patrols or missions	
	Participated in support convoys (e.g. re-supply, VIP escort)	
	Concerned about yourself or others (including allies) having	
	an unauthorised discharge of a weapon	
	Cleared/searched buildings	
	Cleared/searched caves	
In danger of being	In danger of being killed	
killed/injured	In danger of being injured	
Seeing/handling dead bodies	Handled dead bodies	
	Saw dead bodies	
Casualties among those close to you	Heard of a close friend or co-worker who had been injured or killed	
	Present when a close friend was injured or killed	
	Heard of a loved one who was injured or killed	
	Present when a loved one was injured or killed	
Human degradation	Witness to human degradation and misery on a large scale	
Actions resulting in injury or death	Believe your action or inaction resulted in someone being seriously injured	
	Believe your action or inaction resulted in someone being killed	

Table 4.11 shows the types of traumatic deployment experiences for the participants who completed both the pre- and post-deployment self report questionnaire.

Traumatic Deployment Exposure		Number (%) of respondents		
Coming Under Fire	Exposed	918 (69.3%)		
	Unexposed	344 (26.0%)		
	Missing	62 (4.7%)		
Discharging own weapon	Exposed	340 (25.7%)		
	Unexposed	920 (64.5%)		
	Missing	64 (4.8%)		
Unable to respond to a	Exposed	260 (19.6%)		
threatening situation	Unexposed	997 (75.3%)		
	Missing	67 (5.1%)		
Vulnerable situations or fear of	Exposed	886 (66.9%)		
events	Unexposed	378 (28.6%)		
	Missing	60 (4.5%)		
In danger of being	Exposed	610 (46.1%)		
killed/injured	Unexposed	649 (49.0%)		
	Missing	65 (4.9%)		
Seeing/handling dead bodies	Exposed	613 (46.3%)		
	Unexposed	644 (48.6%)		
	Missing	67 (5.1%)		
Casualties among those close	Exposed	766 (57.9%)		
to you	Unexposed	492 (37.2%)		
	Missing	66 (4.9%)		
Human degradation	Exposed	169 (12.8%)		
	Unexposed	1086 (82.0%)		
	Missing	69 (5.2%)		
Actions resulting in injury or	Exposed	96 (7.2%)		
death	Unexposed	1162 (87.8%)		
	Missing	66 (5.0%)		

Table 4.11: Traumatic Deployment Exposure Categories for the pre- post- responders

4.2.6 Traumatic Deployment Experiences Total Score

A total score based on the 26 deployment experiences was also calculated, where 'Never' = 0, 'Once'=1, '2-4 times'=2, '5-9 times'=3 and '10+' = 4. This score, which ranged from 0 to 104, was split up into quartiles to categorise respondents according to the frequency of deployment exposure, where a score of:

- 0-4 = Low exposure
- 5 16 = Medium exposure
- 17 35 = High exposure
- 36 104 = Very High exposure

Table 4.12 shows the number of traumatic deployment experiences for participants who completed both the pre- and post-deployment self report questionnaire.

Number of traumatic exposures (categories)	Number (%) respondents
Low	361 (27.3%)
Medium	276 (20.9%)
High	314 (23.7%)
Very High	313 (23.6%)
Missing	60 (4.5%)

4.2.7 Previous Combat Experience

Previous direct combat exposure was captured in the pre-deployment self-report questionnaire with a dichotomous variable (Yes, No).

Table 4.13 shows the previous combat experience for participants who completed both the pre- and post-deployment self report questionnaire.

Table 4.13: Previous combat	experience f	for the pre-post-	and pre- or	alv sample
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Previous Combat Experience	Number (%) respondents
Yes	182 (13.8%)
No	1087 (82.1%)
Missing	55 (4.1%)

4.3 Summary

Sections two to five will now present and discuss the primary findings.

- Psychological Health Outcomes in Section Two,
- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five

A short introduction at the beginning of each section explains the purpose and provides a brief outline of the theoretical underpinnings informing the analyses within each section. Subsequent chapters within each section focus on a particular outcome of interest.

Each chapter introduces the health outcome of interest by briefly discussing literature before presenting the primary results. At the beginning of each result section, a comparison of the outcome of interest at pre-deployment, for participants who completed only the pre-deployment, with those who completed both the pre-and post-deployment measure is provided. All subsequent analyses within the result sections include only those participants who have completed both the pre- and post-deployment measures. Each chapter concludes with a discussion pertaining to the primary findings.

Section Two - Introduction to Psychological Health

This section focuses on changes to self reported psychological health outcomes between pre- and post-deployment. Each of the chapters in this section considers a specific psychological health outcome, and begins by presenting changes to the prevalence of psychological disorders within the deploying population according to demographic factors such as age, rank, service, roles and deployment location. Recent studies have shown that changes to symptom scores occur along a continuum. A proportion of people have a clinically significant number of symptoms, but not enough to justify a formal diagnosis by the International Statistical Classification of Diseases and Related Health Problems (ICD-10) or Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). These sub-threshold symptoms may result in a degree of disability or dysfunction in both military (1) and non military (2) populations, changes to symptom scores are also provided where relevant. These sub-threshold changes are of interest because their presence may be a marker of increased risk for disorder in some individuals (3).

Each chapter then goes on to present significant findings from the analyses which were based on a number of theoretical underpinnings. First, high levels of co-morbid psychological disorders have been found in both the Australian general and military populations. For example, the 2010 ADF Mental Health and Wellbeing Study, found that one in five ADF members met the criteria for a psychological disorder in the past 12 months and of those approximately 30% suffered from at least two disorder classes (4). Co-morbid disorders were, therefore, considered within the analyses and presented and discussed in the final chapter of this section.

Second, studies have shown that traumatic exposures on deployment, particularly those related to combat roles are associated with increased symptoms of psychological disorders including posttraumatic stress disorder (5), panic disorder and panic attacks (6) as well as suicidal ideation (7). The analyses for this report focused on understanding the relationship between symptoms of psychological disorders and deployment related trauma as well as combat roles. These associations are presented and discussed within each chapter.

Third, while single factors are unlikely to significantly contribute to psychological disorder, individuals may be 'primed' for a delayed affect, whereby the gradual sensitization or kindling as a result of repeated traumatic exposures increase the risk of developing a psychological disorder (8). Therefore, prior traumatic exposures including those that occur outside of the military, are also considered in the analysis and reported where relevant.

There may also be a substantial delay between the exposures and the emergence of any resulting symptoms (9, 10). In some cases, it is only with the passage of time that a symptom threshold sufficient to warrant a clinical diagnosis may be reached. Corresponding changes to neural processing, including the failure of normal neurotransmitter inhibitory mechanisms that quell the stress response (11), could contribute to the risk of this progressive intensification of symptoms and therefore act as an early indicator of risk for the development of a clinical disorder (10). This is particularly important, as subsequent sections within this report, specifically those relating to neurocognitive outcomes, contribute to this hypothesis. The longitudinal methodology used in the MEAO Prospective Study overcomes some of the biases introduced by the cross-sectional studies which have traditionally been used to identify the psychological cost of deployment and combat. These previous studies have often been flawed for two reasons. First, the elapsed time between the exposures and the investigation of health complaints and second, the inability of cross-sectional studies to distinguish between pre-existing psychopathology and that specifically related to the current deployment exposure. The longitudinal methodology used in the MEAO Prospective Study is therefore critical to capturing the trajectories of psychological symptoms (12) and to the establishment of an accurate baseline dataset for further longitudinal surveillance.

The following chapters in this section focus on the psychological health outcomes of interest.

- Chapter Five **Psychological Distress**
- Chapter Six Depressive Symptoms
- Chapter Seven PTSD Symptoms
- Chapter Eight Alcohol Misuse
- Chapter Nine Co-Morbidity and Associations

After providing a short introduction, each chapter describes the measure/s used to identify change, before presenting the primary results. Each chapter concludes with a discussion of these results in relation to the current literature.

Further sections of this report focus on other health outcomes of interest.

- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- Conclusions and Limitations are presented in Chapter Twenty Two

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Chapter Five – Psychological Distress

Key Points

- 1. Just over 70% of participants **scored below the ADF cut-off for psychological distress** at post-deployment, as measured by the K10.
- 2. There was a **statistically significant increase** in psychological distress between pre- and post-deployment.
- 3. This increase was significantly associated with several factors connected to the **most recent deployment**.
- 4. Specifically, these **significant associations** were between increased psychological distress and:
 - a longer deployment period (6 to 7 months and 9 to 12 months but not 8 months)
 - being in a combat role or operating outside of the main support base,
 - reporting a very high number (>35) of deployment exposures; and
 - reporting a number of different traumatic deployment experiences.
- 5. No significant associations were found between increases in psychological distress between pre- and post-deployment, and factors associated with prior deployments.

This chapter presents and discusses the findings relating to changes in psychological distress between pre- and post-deployment. The chapter begins by briefly discussing the current literature pertaining to psychological distress. Results are then provided, beginning with a comparison of the mean pre-deployment psychological distress scores, between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. All subsequent analyses within the result sections include only participants who have completed both the pre-and post-deployment measures. The chapter concludes by discussing the findings pertaining to psychological distress. Other chapters which also present findings pertinent to the focus of this chapter include Chapter Nine (Psychological Co-Morbidity) and Chapter Twenty One (Allostatic Load).

5.1 Introduction

Two important factors need to be considered when identifying the level of psychopathology in this sample. First, it is important that psychopathology be considered both from a categorical and dimensional or continuous perspective, as highlighted by the 2010 ADF Mental Health and Wellbeing Study (1) which found that there was a spectrum of severity of psychological symptoms in the ADF. Second, clinically diagnosable disorders are unlikely to be found immediately after deployment. Instead, symptoms are more likely to increase with time (2), with small

increases in the symptoms of psychological distress after deployment may indicate emerging psychopathology.

Utilising a heterogeneous set of questions that define behavioural, emotional, cognitive and psycho-physiological manifestations of psychological distress, the Kessler 10 scale (K10), developed by Kessler et al (3-5), de-emphasises the need for a specific diagnosis and instead focuses on the level of symptoms and functional impairment. The benefit of this approach, particularly in the post-deployment environment, is that individuals with even mild symptoms can be identified, prior to their condition becoming more severe.

In the recently completed 2010 ADF Mental Health Prevalence and Wellbeing Study (1), the mean K10 score for both deployed and non deployed ADF members (15.4) was already significantly higher than the mean score in a comparison group from the general Australian population (14.1) (6). There is still some debate, however, as to whether deployment related experiences contribute to increased psychological distress. A study by Orme and Kehoe (7) found that similar to the 2010 ADF Mental Health Prevalence and Wellbeing Study (1), 4% of personnel returning from deployment to East Timor reported very high psychological distress (30+) and only 15% reached a cut-off of for moderate psychological distress (20-29). In comparison, a study of 2625 ADF personnel who had deployed to Solomon Islands, East Timor and/or Bougainville, found that deploying even once was related to higher K10 scores in comparison to a non-deployed group (8).

Moderators of psychological distress that have been found in military populations include sex, with females generally reporting higher scores than males, rank, with other ranks reporting higher scores than officers and NCOs, and service, with Navy reporting the lowest mean K10 score (1). The 2007 Australian National Survey of Mental Health and Well Being also found that age influenced K10 scores, peaking at a mean of 15 for the 35 – 44 year age group, before dropping to a mean score of 13.1 for the 75 – 85 age group (9). Similarly, a study of Gulf War veterans and a non-deployed comparison group found that younger Gulf War veterans were more likely to exhibit psychological distress, compared to older non-deployed members (10).

The following sections of this chapter describe the methods used to capture and analyse the levels of psychological distress in the MEAO Prospective Study sample. Results of these analyses are then provided and the key findings discussed in relation to current literature.

5.2 Methods

The primary outcome of interest in this chapter, psychological distress, was measured by the K10 at both pre- and post-deployment within the self-report questionnaire (See Appendix C). Each item of the K10 is scored on a 5-point scale (1=none of the time - 5=all of the time), with K10 scores ranging from 10 to 50. While there are no universally accepted cut-off points on the K10, Sunderland et al (11) suggested that the best fitting model for predicting DSM-IV 12 month disorders was Low 0-5, moderate 6-11, high 12-19 and very high 20+. Similar bands are used by the ADF for post-operational screening where scores between 10 and 14 are considered to be in the low band, 15 to 19 in the medium band and 20+ in the high band (12). In addition to presenting the means, K10 scores have been categorised in accordance with these ADF post-operational screening bands.

5.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and changes in K10 scores from pre- to post-deployment?
- 2. Is there an association between **roles on most recent deployment** and changes in K10 scores from pre- to post-deployment?
- 3. Is there an association between the number and type of **traumatic deployment experiences** while on most recent deployment, and change in K10 scores from pre- to post-deployment?
- 4. Is there an association between **total length of time spent on deployment** in the previous three years and a change in K10 scores from pre- to post-deployment?
- 5. Is there an association between the **number of previous deployments** and a change in K10 scores from pre- to post-deployment?
- 6. Is previous **combat experience** associated with changes in K10 scores from pre- to post-deployment?

5.2.2 Sample Sizes

The total sample size used **to identify change between pre- and post-deployment** psychological distress scores was 1,257. Of the 1,324 participants who completed both a pre- and a post-deployment questionnaire, 67 were excluded - 24 participants did not complete the K10 measure at pre-deployment, 42 did not complete it at post-deployment, and one participant was excluded due to extreme scores, well outside of the expected range at both pre- and post-deployment.

The total sample size used **to compare the mean pre-deployment K10 scores** for pre-deployment only participants, with pre- and post-deployment participants, was 533. Of the 547 participants who only completed a pre-deployment questionnaire, 14 participants did not complete the K10 measure at pre-deployment.

There may also be some variation to the sample sizes used within each of the result sections due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

5.2.3 Data Analysis

Two analytical strategies were used in this chapter. First, a mixed model for repeated measures was used to analyse continuous K10 scores. This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post-deployment) and their interaction(s) are included as fixed effects in the model.

Second, scores on the K10 were categorised into three severity bands (Low, Moderate, High) at pre- and post-deployment. Step-wise change across bands (1 step, 2 step) between pre- and post-deployment was then calculated for each participant. For the purposes of modelling, these changes were then simplified into three change categories ('Increase', 'Decrease' or 'No change'). The change categories were then used as a three level categorical outcome in a multinomial logit model. This approach allowed for the shift in severity of symptoms between the two

time points to be examined. In all models the default reference category was 'No Change'. Where a different reference category was used, this is stated in the text.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

5.3 Results for Psychological Distress

Analysis of the mean pre-deployment K10 scores for respondents who only completed a pre-deployment survey, and those who completed a pre- and post-deployment survey was also undertaken (see Table 5.1, Appendix L). Pre-deployment mean K10 scores were significantly higher (p=0.04) for respondents who only completed a pre-deployment survey compared to those who completed both a pre- and post-deployment survey (mean difference 0.7, 95% CI 0.2, 1.1).

For respondents who completed K10 at both pre- and post-deployment, the mean K10 scores were 13.2 and 13.9 respectively (difference = 0.7, 95% Cl 0.5, 1.0), and this change was statistically significant (p<0.0001) (see Table 5.2, Appendix L). The distribution of mean change between pre- and post-deployment is depicted in Figure 5.1.





The number and percentage of pre- and post-deployment responders in each K10 risk category (low = 10-14; medium = 15-19; High = 20+) is presented in Table 5.3.

	К10		Total N		
		Low N(%)	Moderate N(%)	High N(%)	
Pre	Low	761 (60.5%)	129 (10.3%)	60 (4.8%)	950
	Moderate	96 (7.5%)	66 (5.3%)	45 (3.6%)	207
	High	31 (2.5%)	29 (2.3%)	40 (3.2%)	100
Total N		888	224	145	1257

Table 5.3: Change in each K10 ban	between pre- and post-deployment
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While 69.0% (n = 867) of these responders did not change K10 bands between preand post-deployment, 18.6% (n = 234) of respondents increased at least one band, while 12.4% (n = 156) of responders decreased at least one band (see Tables 5.4 and 5.5, Appendix L).

Table 5.6 presents the change according to the epidemiological cut-offs developed by the 2010 Mental Health and Wellbeing Survey (1). These cut-offs are designed to bring the number of false positives and false negatives closest together and therefore is the closest estimate to the true prevalence of any 30-day ICD-10 affective disorder.

К10			Post			
		Below epi- cut-off	Above epi- cut-off (≥25)			
Pre	Below epi-cutoff	1173 (93.3%)	52 (4.1%)	1225		
	Above epi-cutoff (≥25)	23 (1.8%)	9 (0.7%)	32		
Total N		1196	61	1257		

Table 5.6: Change in K10 using epidemiological cut-offs developed by the 2010 Mental Health andWellbeing Survey between pre- and post-deployment

Of most interest in this table, is the number of participants who met the epidemiological cut-off at post-deployment (n=61).

5.3.1 Length of Recent Deployment

There was no association between the length of most recent deployment and the change in mean K10 scores between pre- and post-deployment. The means for the effect of length of recent deployment on K10 scores are presented in Table 5.7 Appendix L.

An analysis of the percentage of participants in each K10 change category (Increase, Decrease, No Change) for the different 'length of recent deployment' categories was also conducted (Table 5.8).

Length of Recent Deployment	N	K10 Increase	K10 Decrease	K10 No change
<= 5 Months	385	12.0%	10.9%	77.1%
6-7 Months	387	19.6%	11.9%	68.5%
8 Months	273	16.5%	10.6%	72.9%
9-12 Months	212	19.8%	9.0%	71.2%

Table 5.8: Proportion of participants in each K10 change category by length of most recentdeployment

Using '<=5 months' as the predictor reference, and 'no change' as the outcome reference, there was a significant association between the length of recent deployment and K10 change categories (p=0.05). Those who were deployed for 6 to 7 months (OR=1.94, 95% CI 1.27, 2.96, p=0.002) and those that deployed for 9 to 12 months (OR=1.92, 95% CI 1.16, 3.19, p=0.01) had a greater proportion of increased K10 scores compared to those who were deployed for less than or equal to 5 months. There was a similar, though not significant pattern for those who had deployed for 8 months compared to <=5 months (OR=1.55, 95% CI 0.95, 2.54, p=0.07).

The significant effect of length of recent deployment is illustrated in Figure 5.2. This shows that the probability of psychological distress increasing, decreasing or not changing for increasing length of recent deployment. A smaller proportion of people whose psychological distress increased had been deployed for equal to or less than 5 months.



Figure 5.2: Predicted proportion of participants by length of most recent deployment, for each K10 change category. * Note this plot is computed at the average level of Age (31.12) and the reference level for gender (Male), service (Army) and rank (Other Ranks).

5.3.2 Role on Recent Deployment

The means for the effect of role on changes to K10 scores between pre- and postdeployment are presented in Table 5.9.

Role on recent	Ν	Pre-deployment	Post-deployment	Change
deployment		(95% CI)	(95% CI)	(95% CI)
Combat Afghan &	644	13.38	14.53	1.15
Outside MSB		(12.66, 14.10)	(13.77, 15.30)	(0.76, 1.54)
Inside MSB	289	13.64	14.12	0.48
		(12.96 <i>,</i> 14.33)	(13.35, 14.90)	(-0.10, 1.06)
Outside Afghan	324	13.56	13.78	0.22
		(13.00, 14.12)	(13.12, 14.44)	(-0.03, 0.77)

Table 5.9: Mean (95% CI) K10 score for each combination of survey time and role on deployment

As can be seen in Table 5.9, the increase in mean K10 scores between pre- and post-deployment was greater for those in a combat role or who operated outside a main support base, than the change in mean K10 score for those whose role was inside a main support base (p=0.06) and for those Outside Afghan (p=0.007) (see Figure 5.3).



Figure 5.3 Change in mean K10 scores between pre- and post-deployment for each role on most recent deployment

An analysis of the percentage of participants in each K10 change category (Increase, Decrease, No Change) for the different 'role on most recent deployment' categories, was also conducted (Table 5.10, Appendix L). Using 'Outside Afghan' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between the role on most recent deployment and K10 scores.

5.3.3 Number of Traumatic Deployment Exposures

The effects of number of traumatic deployment exposures on changes to mean K10 scores between pre- and post-deployment (n = 1221) are presented in Table 5.11.

Deployment exposure (category)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
Low	351	13.46	13.62	0.16
		(12.92, 14.00)	(12.99, 14.25)	(-0.36, 0.67)
Medium	268	13.79	14.46	0.67
		(13.12, 14.46)	(13.70, 15.23)	(0.08, 1.27)
High	300	13.59	14.32	0.73
		(12.83, 14.35)	(13.48, 15.15)	(0.17, 1.29)
Very High	302	13.69	15.09	1.40
		(12.90, 14.48)	(14.23, 15.95)	(0.84, 1.96)

 Table 5.11: Mean (95% CI) K10 score for each combination of survey time and number of traumatic

 deployment exposures

As can be seen in Table 5.11, the change in K10 scores was significantly different between the four categories of deployment exposure (p=0.02). This difference is most likely due to Very High category, which showed the greatest increase in K10 scores between pre- and post-deployment (see Figure 5.4).



Figure 5.4: Mean K10 score at each survey time for each level of deployment exposure

The proportion of participants with increases, decreases or no change for each number of deployment exposure scores are presented in Table 5.12.

Deployment exposure (category)	N	K10 Increase	K10 Decrease	K10 No change
Low	351	13.1%	10.8%	76.1%
Medium	268	17.2%	11.6%	71.2%
High	300	16.3%	11.7%	72.0%
Very High	302	19.9%	8.9%	71.2%

 Table 5.12: Proportion of participants in each K10 change category by number of deployment exposures

Using 'Low exposures' as the predictor reference, and no change as the outcome reference, there was a significant association between the number of deployment exposures, and the change in K10 scores between pre- and post-deployment. Those who had medium (p=0.03, OR=1.80, 95%CI 1.04, 3.61), high (p=0.03, OR=1.94, 95%CI 1.04, 3.61) and very high (p=0.005, OR=2.43, 95%CI 1.30, 4.56) numbers of deployment exposures, were more likely to increase in K10 scores between pre- and post-deployment, compared to those who had the lowest number of deployment exposures.

The significant effect of number of deployment exposures is illustrated in Figure 5.5. which shows the probability of psychological distress increasing, decreasing or not changing for increasing numbers of exposures. It can be seen that the proportion of the people whose psychological distress increased, was larger as number of deployment exposures increased.





5.3.4 Traumatic Deployment Experiences

The proportion of respondents who had indicated at least one exposure to each of the nine categories of deployment experiences are summarised in Table 5.13, along with associated change in K10 scores between pre- and post-deployment (n = 1221). Note that each respondent could have responded positively to more than one item.

Table 5.13: Proportion of respondents who answered at least one exposure and the change in meanK10 scores between pre- and post-deployment.

Deployment experiences		Exposed	Unexposed		
	N	Change K10 score	N	Change K10 score	
	(%)	(95% CI)	(%)	(95% CI)	
Coming under fire	887	0.98	333	0.03	
	(72.7%)	(0.65, 1.30)	(27.3%)	(-0.50, 0.56)	
Vulnerable situations or fear of events	852 (69.8%)	0.95 (0.62, 1.29)	369 (30.2%)	0.17 (-0.33, 0.68)	
Casualties among those close to you	738	0.94	478	0.39	
	(60.7%)	(0.58, 1.29)	(39.3%)	(-0.06, 0.83)	
In danger of being killed/injured	585	1.29	632	0.18	
	(48.1%)	(0.89, 1.69)	(51.9%)	(-0.21, 0.56)	
Seeing/handling	593	0.99	622	0.47	
dead bodies	(48.8%)	(0.59, 1.39)	(51.2%)	(0.08, 0.86)	
Discharging own	325	1.06	893	0.60	
weapon	(26.7%)	(0.52, 1.60)	(73.3%)	(0.27, 0.92)	
Unable to respond to a threatening situation	246 (20.3%)	1.40 (0.78, 2.02)	969 (79.8%)	0.54 (0.23, 0.85)	
Human degradation	160	2.07	1053	0.52	
	(13.2%)	(1.31, 2.83)	(86.8%)	(0.22, 0.81)	
Actions resulting in	93	1.02	1123	0.70	
injury or death	(7.7%)	(0.02, 2.03)	(92.4%)	(0.41, 0.99)	

Coming under fire, exposure to vulnerable situations or fear of events and casualties among those close to you, were the most common deployment experiences reported by respondents.

Participants who reported either coming under fire (p=0.003), exposure to vulnerable situations or fear of events (p=0.01), being in danger of being killed/injured (p<0.0001), being unable to respond to a threatening situation (p=0.01), or experiencing human degradation (p=0.002) were significantly more likely to record greater changes in K10 scores, on average, between pre- and post-deployment, in comparison to those who did not report the traumatic experience.

The proportion of respondents in each K10 change category (Increase, Decrease, No Change), who had indicated Yes or No to at least one exposure to each of the nine categories of deployment experiences is summarised in Table 5.14. Note that each respondent could have responded positively to more than one item.

Deployment experiences	Exposed		Unexposed							
	Yes N	Percentage	K10 Increase	K10 Decrease	K10 No change	No N	Percentage	K10 Increase	K10 Decrease	K10 No change
Coming under fire	887	72.7%	13.3%	10.3%	72.4%	333	27.3%	14.4%	11.7%	73.9%
Vulnerable situations or fear of events	852	69.8%	18.4%	10.6%	71.0%	369	30.2%	11.9%	11.1%	77.0%
Casualties among those close to you	738	60.7%	18.0%	10.7%	71.3%	478	39.3%	14.0%	10.5%	75.5%
In danger of being killed/injured	585	48.1%	18.6%	9.1%	72.3%	632	51.9%	14.4%	12.2%	73.4%
Seeing/handling dead bodies	593	48.8%	17.0%	9.4%	73.6%	622	51.2%	15.9%	11.7%	72.4%
Discharging own weapon	325	26.7%	18.2%	10.1%	71.7%	893	73.2%%	15.9%	11.0%	73.1%
Unable to respond to a threatening situation	246	20.3%	22.0%	11.8%	66.3%	969	79.7%	15.1%	10.4%	74.5%
Human degradation	160	13.2%	26.3%	11.3%	62.4%	1053	86.8%	14.9%	10.5%	74.6%
Actions resulting in injury or death	93	7.7%	19.4%	12.9%	67.7%	1123	92.3%	16.2%	10.4%	73.4%

Table 5.14: Comparison of proportion of respondents in each K10 change category who did and did not report an experience within the exposure category.

Using 'No exposure' as the predictor reference, and 'No change' as the outcome reference, participants who reported 'exposure to vulnerable situations or fear of events' (p=0.0006, OR=2.35, 95%CI 1.45, 3.82), or 'experiencing human degradation' (p=0.0002, OR=2.22, 95%CI 1.46, 3.35), were more likely to increase in K10 category compared to those participants who did not report these experiences.

When the outcome reference was changed to decrease, those who reported 'exposure to vulnerable situations or fear of events' were again significantly more likely to increase compared to decrease (p=0.01, OR=2.31, 95%CI 1.17, 4.57) in K10 category. Furthermore, those who had reported being in 'danger of being killed or injured' were also more likely to increase in K10 scores between pre- and post-deployment, compared to decrease (p=0.006, OR=2.10, 95%CI 1.23, 3.57).

5.3.5 Total Time on Deployment in Previous Three Years

The means for the association between prior deployments and changes to K10 scores between pre- and post-deployment (n = 933) are presented in Table 5.15 (Appendix L). While K10 scores did increase, on average, over time between preand post-deployment, this increase was not significantly different between the four different categories of total time on previous deployments over the last 3 years.

An analysis of the percentage of participants in each K10 change category (Increase, Decrease, No Change) for the different 'total time on prior deployment' categories (n = 933) was also undertaken (Table 5.16, Appendix L). Using 'None' as the predictor reference and 'No change' there was no association between time away on prior deployments and change in K10 scores.

5.3.6 Number of Prior Deployments

The means for the effect of prior deployments on changes to K10 scores are presented in Table 5.17 (Appendix L). The change in K10 scores between pre- and post-deployment was not significantly different between the four prior deployment categories (n = 1137).

An analysis of the percentage of participants in each K10 change category (Increase, Decrease, No change) for the different 'number of prior deployment' categories was also completed (Table 5.18, Appendix L). Using 'None' as the predictor reference, and 'No change' as the outcome reference, there was no significant difference in the proportion of participants in each K10 change category, for each prior deployment category.

5.3.7 Previous Combat Exposure

The means for the effect of previous combat exposure on changes to K10 scores between pre- and post-deployment (n = 1221) are presented in Table 5.19 (Appendix L). The difference between the change in K10 scores between pre- and post-deployment was not significantly different between those who were exposed to prior combat and those who were not.

An analysis of the percentage of participants in each K10 change category for participants who had, and had not had previous combat exposure, was also conducted (Table 5.20, Appendix L). Using 'Yes' as the predictor reference, and 'no change' as the outcome reference, also did not identify any significant association between previous combat exposure and changes in K10 scores.

5.4 Summary of Results

Table 5.21 summarises the key findings presented in this results section in relation to the questions posed in section 5.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Length of most recent deployment	Compared to those away for ≤ 5 months, those away for 6 to 7 months and 9 to 12 months were likely to have a greater increase in K10 scores between pre- and post-deployment.
Q2. Role on most recent deployment	The increase in mean K10 scores between pre- and post-deployment was greater for those in a combat role or who operated outside a main support base, than for those whose role was inside a main support base and those who were Outside Afghan.
Q3a. Number of traumatic deployment	Those participants who had a Very High number of traumatic deployment exposures showed the greatest increase in K10 scores between pre- and post-deployment.
exposures	The proportion of participants' whose psychological distress increased was larger with higher numbers of deployment exposures.
Q3b. Traumatic deployment experiences	Participants who reported either coming under fire, exposure to vulnerable situations or fear of events, being in danger of being killed/injured, being unable to respond to a threatening situation, or experiencing human degradation had significantly greater increases in K10 scores between pre- and post-deployment, compared to those without these exposures.
	The proportion of participants whose psychological distress increased was greater for those who reported exposure to vulnerable situations or fear of events, experiencing human degradation and/or being in danger of being killed or injured, compared to those without these exposures.
Q4. Total time on prior deployments	Nil
Q5. Number of prior deployments	Nil
Q6. Previous combat exposure	Nil

Table 5.21: Summary	of key	v findings	presented in	this chapter
	OT NC	1	presented in	this chapter

5.5 Discussion

The overall mean K10 score for participants who completed both the pre- and postdeployment K10 was 13.2 at pre-deployment and 13.9 at post-deployment and this difference was significant. However, both the pre- and post-deployment mean K10 scores were lower than the mean scores (15.4) reported in the recently completed 2010 ADF Mental Health Prevalence and Wellbeing Study (1). They were also lower than the mean K10 score of 14.1 reported by the Australian Bureau of Statistics 2007 National Survey of Mental Health and Well Being (6). A comparison with respondents who completed only the pre-deployment self-report questionnaire found that there was a significant difference between these groups in mean K10 scores at pre-deployment. On average, those respondents who only completed a self-report questionnaire at pre-deployment had higher psychological distress than those who completed both a pre- and post-deployment self report questionnaire.

Using the establish ADF cut-offs, 7.9% of participants who completed both a pre- and post-deployment questionnaire fell within the high (20+) band (n = 100) at predeployment, while 11.5% of participants reported a score within this high band at post-deployment (n = 145). The percentage of respondents reporting high levels of psychological distress in this study is lower than the Mental Health Prevalence and Wellbeing Study (1) which found that 12.9% of ADF members (deployed and nondeployed) reported high or very high psychological distress (22+).

Other Deployment Health Surveillance Program studies used a much higher cut-off (30+) to identify prevalence rates for psychological distress. For example, the MEAO Census Study found that 4.2% of ADF members deploying to the MEAO before December 2009 met the criteria for high levels of psychological distress (13). In the Bougainville Post-deployment Health Study (14), 5% of veterans and 7% of non-deployed comparisons reported high levels of psychological distress. Similar results were found for the East Timor study, with 7% of veterans and 5% of a non-deployed comparison group reporting very high levels of psychological distress (15).

It is perhaps not surprising that 75.6% of respondents at pre-deployment and 70.7% of respondents at post-deployment reported K10 scores that fall within the low band as categorised by the ADF post-operational screen. A number of previous studies have identified that clinically diagnosable disorders are unlikely to be found within the first few months post-deployment. Instead, symptoms are likely to increase with time (2), with increases in psychological distress after deployment likely to be indicators of emerging psychopathology.

5.5.1 Associations with Change Between Pre- and Post-Deployment

The changes in psychological distress between pre- and post-deployment, as measured by the K10, were significantly associated with a number of factors including length of most recent deployment, role type, specifically combat roles and also those responders operating outside of the main support base. In addition, the number and type of traumatic deployment experiences was also associated with increases in psychological distress.

5.5.2 Length of Most Recent Deployment

Similar to other studies involving ADF personnel (16), the association between deployment and psychological distress in the MEAO Prospective Study was not conclusive. While the association between change in mean K10 scores and length of time on most recent deployment was not, the association between K10 change category (Increase, Decrease, No Change) was statistically significant.

This difference between the two types of outcomes may reflect the different approaches to analysis. While the mean (continuous) score was averaged across different types of change (i.e. increase or decrease), categorical outcomes were treated as separate groups. In comparison to those deployed for five or less months, those respondents who were deployed for six to seven months, and those that deployed for nine to 12 months, were more likely to have an increase in psychological distress between pre- and post-deployment than stay the same, and

this result was statistically significant. However, in comparison to those deployed for five or less months, the likelihood that respondents who were deployed for eight months would have an increase in K10 scores compared to a decrease between preand post-deployment, was only marginally significant.

The suggestion that the association between time away on deployment and the likelihood of increases in psychological distress may not be linear supports findings from other ADF studies. For example, ADF members deployed to Solomon Islands, East Timor and/or Bougainville reported a non-linear relationship between K10 scores and time away on deployment. While deploying for between 8 and 10 months increased the odds of scoring 20 on the K10, compared to deploying for up to three months, this was not the case for people who deployed for 11 to 36 months in comparison (8).

5.5.3 Role on Most Recent Deployment

The relationship between combat role or working outside the main support base and increases in psychological distress, measured by the change in the mean K10 score, was statistically significant. While other studies have also identified an association between combat in Iraq and Afghanistan and a number of psychological disorders including depression (17) and PTSD (18), the literature looking at the specific associations between psychological distress and combat in the MEAO is somewhat limited. One exception, is a study involving UK military personnel deployed to Iraq and/or Afghanistan which found no association between combat and increases in psychological distress measured by the 12-item General Health Questionnaire (GHQ-12). The authors suggested that this may have been because these troops did not experience high intensity combat in comparison to other military cohorts, and/or alternatively the benefits of deployment such as carrying out the types of duties that they were trained for counterbalanced any that may have lead to psychological morbidity (19, 20).

5.5.4 Deployment Related Trauma

In the current study, as the number of traumatic deployment exposures increased, so too did psychological distress. In addition, those people with specific exposures such as coming under fire, exposure to 'vulnerable situations or fear of events', 'being in danger of being killed/injured', 'being unable to respond to a threatening situation' and 'experiencing human degradation' also reported significantly greater increases on average, in psychological distress between pre- and post-deployment.

An analysis of the K10 change category (Increase, Decrease, No Change) and trauma categories, found a similar pattern of results: in comparison to no exposures, participants who reported being exposed to 'vulnerable situations or fear of events' and 'experiencing human degradation' were also more likely to report an increase in psychological distress between pre- and post-deployment. In addition, those participants who reported 'being in danger of being killed or injured' were more likely to report an increase in psychological distress between pre- and post-deployment, in comparison to reporting a decrease.

Once again, there is limited literature looking specifically at psychological distress and traumatic exposures in military populations. The primary exception to this was the MEAO Census Study (13), which found that the two experiences that were associated with highest psychological distress (K10 \ge 30) across both Iraq and Afghanistan deployed ADF military personnel were 'being in a threatening situation and unable to respond' and 'witnessing human degradation'. Both of these were also associated with increases in psychological distress in the MEAO Prospective Study. A considerable number of studies have also looked at the association between psychological distress and civilian trauma (21-23). Of particular interest is research looking at outcomes from trauma in the New Zealand general population (24), which found that, as with the MEAO Prospective Study, particular types of trauma rather than trauma per se, impacted on an individual's psychological health. For example, the study found that exposure to crime was associated with an increase in psychological distress while involvement in a motor vehicle accident was not associated with increased psychological distress as measured by the Mental Health Inventory.

5.6 Summary

This study has shown that operating in a combat role or outside of the main support base was associated with an increase in psychological distress on average, between pre- and post-deployment. In addition, the study found that increases in psychological distress were associated with the number and type of traumatic deployment exposures experienced on the respondents' most recent deployment. However, while increases in psychological stress were statistically significant, only a small percentage of respondents (4.8%) increased from low to high psychological distress between pre- and post-deployment. Further research is required to identify whether these increases are suggestive of longer-term morbidity or alternatively whether symptoms will decrease over time.

The next chapter focuses on **depressive symptoms** (Chapter Six). Once again, after providing a short introduction, an explanation of the primary measures is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature. Further chapters included within Section Two are:

- Chapter Seven **PTSD Symptoms**
- Chapter Eight Alcohol Misuse
- Chapter Nine **Co-Morbidity**

Following sections of this report focus on other health outcomes of interest.

- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five

5.7 Other Chapters of Relevance

- Chapter Nine Psychological Co-Morbidity at Post-Deployment
- Chapter Twenty One Allostatic Load

5.8 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

• Is there an interaction between the various deployment-related factors, age and prior exposures, on symptoms of psychological distress?

- What factors are associated with different trajectories of psychological distress (decreasing, stable and increasing symptoms) between pre- and post-deployment?
- What are the potential reasons for variations in psychological distress between groups with different deployment lengths? In particular, what might set apart those that were deployed for 8 months in comparison to those that were deployed for 6 to 7 months and 9 to 12 months.
- What is the impact of the pre-deployment symptom interpretation questionnaire, on the pattern of psychological distress symptom reporting?
- Is there a hierarchy of psychological distress symptoms that emerges in the postdeployment environment?

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Chapter Six – Depressive Symptoms

Key Points

- 1. Just over 80% of participants scored below the cut-off for moderate depressive symptoms at post-deployment.
- 2. Increases in depressive symptoms between pre- and post-deployment were significantly associated with several factors connected to the **most recent deployment**.
- 3. Specifically, these **significant associations** were between increased depressive symptoms and:
 - being in a combat role or operating outside of the main support base,
 - reporting a number of different traumatic deployment experiences; and
 - reporting a very high number (>35) of deployment exposures.
- 4. No significant associations were found between increases in depressive symptoms between pre- and post-deployment, and factors associated with prior deployments.

This chapter presents and discusses the findings relating to changes in depressive symptoms between pre- and post-deployment. The chapter begins by briefly discussing current literature pertaining to depression, before providing details about the principal measure used to assess depressive symptoms in the MEAO Prospective Study. Primary results are then provided, beginning with a comparison of the pre-deployment results between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. All subsequent analyses presented within the result section include only those participants who completed both the pre- and post-deployment measures. The chapter concludes by discussing the primary findings pertaining to depressive symptoms. Findings pertinent to the focus of this chapter are also included in Chapter Nine (Psychological Co-Morbidity).

6.1 Introduction

Depression is a disorder that deserves particular concern in military populations, with the increasing recognition that traumatic stress plays an important role in the onset of the disorder [1]. Furthermore, depressive disorders are the number one cause of disability globally [2], and are associated with increased mortality from suicide and some physical conditions. The 2007 Australian National Survey of Mental Health and Wellbeing found that in any given year, 3.1% of Australian men and 5.1% of women experience a depressive episode, equating to an annual prevalence rate of 4.1% in the general population [3]. For many people, depression is a chronic, recurrent condition with a significant rate of relapse [4]. Depression is also one of the most commonly reported mental illnesses in military personnel. McFarlane et al. [5]

reported the annual prevalence rate of depression in ADF troops (6.4%) to be roughly double that seen in the Australian community. Previous studies in the ADF context have highlighted the prevalence of depression. A study of the Gulf War 1990-91 veterans found that in the 10 year post-deployment period, 18% of the veterans had developed an affective disorder, in contrast to 12% of the comparison group. A much smaller proportion of veterans had developed PTSD (5.4%), emphasising that PTSD is not the only disorder of concern in deployed samples [6].

The literature identifies a number of demographic risk factors for the occurrence of depression which are relevant to military populations. Male personnel have been found to have significantly higher rates of depression than Australian men generally [7]. In contrast to the general community, however, there were no significant differences between male and female troops in the prevalence of depression [7]. While depression rates have generally been found to be similar across age groups in military populations [8, 9], at least one study reported higher rates among younger compared to older military personnel [10]. Some studies have found higher rates of depression among single [11], and divorced or separated personnel, compared to their married/defacto colleagues [12]. Finally, depression rates are also generally higher among those of lower ranks [12, 13].

Military specific risks for depression include deployment, combat exposure and specific combat experiences. Findings have, however, been inconsistent for the specific impact of deployment. For example, Shen et al [14] found a small but significant positive relationship between length of deployment and post-deployment depression. Rona et al. [15] also found that both the length and number but not frequency of deployments were associated with depressive symptoms. In contrast, Wells et al. [16] found personnel who deployed without combat exposure reported *lower* levels of depression compared to those who did not deploy, suggesting a 'healthy soldier effect'. Importantly, those who deployed and experienced combat exposures were more likely to experience new-onset depression than those who did not deploy [16]. Therefore, it is likely that combat exposure and specific combat experiences, rather than deployment itself, are associated with depression.

A number of studies have provided support for a combat exposure–depression link. van Zuiden et al. [17] found a relationship between the amount of stressors and combat experiences while on deployment and depression symptoms post-deployment. Sareen et al. [18] found personnel deployed on *combat operations* had significantly higher odds of developing depression compared to those who had not been deployed. Furthermore, those troops who had witnessed atrocities or massacres had the highest odds of meeting diagnostic criteria for depression [18]. Providing further evidence for the differential effects of specific combat experiences rather than just combat exposure, Maguen et al. [19] found that while neither witnessing killing nor reported killing were predictors of subsequent development of depression symptoms, perceived danger, and exposure to death and dying were.

The role of deployment exposures is important to the aetiology of depression due the the mechanisms of stress sensitization [20]. For many years, it has been recognised that the development of major depression involves both stressful events and genetic risk factors. Sensitisation is the process, resulting from a number of stressful events over time, which may predict the onset of depressive states. A recent meta-analysis [21], found that a first episode of major depression was more likely to be preceded by significant psychological stress. However, these same triggers may not be necessary for subsequent depression. For deployed personnel who have already been exposed to prior stressful events, the recruitment of depressive symptoms is likely to have important implications for the risk of future mood disorder.

6.2 Methods

The primary outcome of interest in this chapter is depressive symptoms, measured at pre- and post-deployment using the PHQ-9 in the self report questionnaire. The questions specifically relate to changes in depressive symptom severity (see Appendix C). Each item of the PHQ-9 is scored on a 4-point scale (0=not at all, 1=several days, 2=more than half the days, 3=nearly every day), with PHQ-9 scores ranging from 0 to 27 (minimal = 0 to 4, Mild = 5 to 9, Moderate = 10 to 14, Moderately Severe = 15 to 19 and Severe = 20 to 27) [22]. As these bands are commonly used by researchers, comparisons with other studies can be undertaken in the future.

It is important to note that meeting the criteria for depression syndrome does not equate to a DSM IV affective disorder. In order to make such a diagnosis, other criteria would need to be ascertained by a clinical interview. The following discussion relates to changes in depressive symptom severity rather than the presence of a clinical disorder.

6.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and a change in depressive symptoms between pre- and post-deployment?
- 2. Is **role on most recent deployment** associated with a change in depressive symptoms between pre- and post-deployment?
- 3. Is there an association between the type and number of **traumatic deployment experiences** and changes in depressive symptoms between pre- and post-deployment?
- 4. Is there an association between **total length of time spent on deployment** in the previous 3 years and a change in depressive symptoms between preand post-deployment?
- 5. Is there an association between **the number of previous deployments** and a change in depressive symptoms between pre- and post-deployment?
- 6. Is **previous combat exposure** associated with a change in depressive symptoms between pre- and post-deployment?

6.2.2 Sample Sizes

The total sample size used **to identify change between pre- and post-deployment** depression severity was 1,209. Of the 1324 participants who completed a pre- and a post-deployment questionnaire, 115 were excluded - 30 participants did not complete the PHQ-9 measure at pre-deployment, 83 did not complete the PHQ-9 at post-deployment, and 2 did not complete the PHQ-9 at either pre- or post-deployment.

The total sample size used **to compare the pre-deployment PHQ-9 scores** for predeployment only participants, with pre- and post-deployment participants, was 524. Of the 547 participants who completed a pre-deployment questionnaire only, 23 participants did not complete the PHQ-9 measure at pre-deployment.

There may also be some variation to the sample sizes used for specific analyses due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

6.2.3 Data Analysis

Scores on the PHQ-9 were categorised into 5 severity bands (Minimal, Mild, Moderate, Moderately Severe, Severe) at pre-deployment and post-deployment.

Stepwise change across bands (1 step, 2 step, 3 step, 4 step) between pre- and post-deployment was then calculated for each participant. For the purposes of modelling, these changes were then simplified into three change categories ('Increase', 'Decrease' or 'No change'). Percentages of respondents for all three forms of data (severity bands, stepwise change, and change categories) are presented in the descriptive tables, and the distribution of these is described below.

The change categories were then used as a three level categorical outcome in a multinomial logit model. This approach allowed for the shift in severity of symptoms between the two time points to be examined. In all models the default reference category was 'no change'. Where a different reference category was used, this is stated in the text.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

6.3 Results

A comparison of the percentage of respondents in each PHQ-9 risk category, between those who only completed a pre-deployment survey, and those who completed a pre- and post-deployment survey was also undertaken (see Table 6.1, Appendix M). Compared to those who completed both a pre- and post-deployment survey, there were 2.7% fewer pre-deployment only respondents in the minimal band, 0.6% more in the mild band, 1.8% more in the moderate band, and 0.3% more in the severe band.

The number and percentage of pre- and post-deployment responders in each PHQ-9 risk category (minimal = 0 to 4, Mild = 5 to 9, Moderate = 10 to 14, Moderately Severe = 15 to 19 and Severe = 20 to 27) is presented in Table 6.2.

	PHQ Post 1						Total
		Minimal N(%)	Mild N(%)	Moderate N(%)	Moderate Severe N(%)	Severe N(%)	N
Pre	Minimal	936 (77.3%)	136 (11.2%)	19 (1.5%)	10 (0.7%)	2 (0.2%)	1103
	Mild	41 (3.4%)	29 (2.4%)	13 (1.1%)	4 (0.4%)	5 (0.4%)	92
	Moderate	2 (0.2%)	2 (0.2%)	1 (0.1%)	1 (0.1%)	0 (0.0%)	6
	Moderate Severe	1 (0.1%)	0 (0.0%)	2 (0.2%)	1 (0.1%)	1 (0.1%)	5
	Severe	0 (0.0%)	1 (0.1%)	0 (0.0%)	0 (0.0%)	2 (0.2%)	3
	Total N	980	168	35	16	10	1209

Table 6.2 Change	in PHQ-9 risk	category between	pre- and r	post-deployment

For respondents who completed PHQ-9 at both pre- and post-deployment, the vast majority (91.2%) had minimal depressive symptoms at pre-deployment. A further 7.6% (n = 92) reported mild symptoms, and 1.2% (n = 15) had symptoms ranging from moderate to severe. At post-deployment there was a general trend towards an increase in depressive symptoms, with the percentage of respondents in the minimal band reducing to 81.1% (n = 968), those in the mild category almost doubling to 13.9% (n = 168), and a fourfold increase, up to 5%, across the moderate to severe categories (n = 60).

Overall, 80.1% (n = 969) of respondents did not change PHQ-9 risk bands between pre- and post-deployment (see Tables 6.3 and 6.4, Appendix M). However, 15.8% (n = 191) of respondents increased at least one band, and 4.1% (n = 49) decreased one or more bands, between pre- and post-deployment (see Table 6.4, Appendix M).

6.3.1 Length of Most Recent Deployment

Table 6.5 (Appendix M) shows the percentage of participants in each PHQ-9 change category (Increase, Decrease, No change) for the different 'Length of recent deployment' categories (n = 1209). Using '<=5 Months' as the predictor reference, and 'No change' as the outcome reference, there was no association between the length of most recent deployment and PHQ-9 change.

6.3.2 Role on Most Recent Deployment

Table 6.6 shows the percentage of participants in each PHQ-9 change category for each role on most recent deployment.

Role on recent	N	PHQ-9	PHQ-9 Decrease	PHQ-9 No
deployment		Increase		change
Combat Afghan & Outside MSB	618	17.2%	3.1%	79.7%
Inside MSB	280	15.7%	5.0%	79.3%
Outside Afghan	311	13.2%	5.1%	81.7%

Table 6.6 Percentage of participants in PHQ-9 change category for each role.

Using 'Outside Afghan' as the predictor reference, and 'No change' as the outcome reference, there was a significant association between role on most recent deployment and PHQ-9 change (p=0.01). As can be seen in Table 6.6, a greater proportion of participants in a combat role or who worked outside the main support base increased in PHQ-9 compared to those who worked inside the main support base or outside of Afghanistan (OR=1.93, 95% CI 1.04, 3.60). This association is illustrated in Figure 6.1.



Figure 6.1 Predicted proportion of respondents in each PHQ-9 change category, for each role on recent deployment. * Note this plot is computed at the average level of Age (31.12) and the reference level for gender (Male), service (Army) and rank (Other Ranks).

6.3.4 Number of Traumatic Deployment Exposures

The percentage of participants in each PHQ-9 change category for the different numbers of deployment exposures are presented in Table 6.7.

Deployment exposure (category)	N	PHQ-9 Increase	PHQ-9 Decrease	PHQ-9 No change
Low	341	12.3%	5.9%	81.8%
Medium	264	18.6%	2.7%	78.7%
High	291	13.1%	3.8%	83.1%
Very High	298	19.1%	3.4%	77.5%

Table 6.7 Percentage of participants in each PHQ-9 change category for each number of deployment exposures

Using 'Low exposures' as the predictor reference, and no change as the outcome reference, there was a significant association between number of deployment exposures and PHQ-9 change (p=0.003). Those respondents who had the highest number of deployment exposures were more likely to increase in PHQ-9 compared to those who had the lowest number of deployment exposures (OR=2.65, 95%CI 1.40, 5.02). This association is illustrated in Figure 6.2.



Figure 6.2 Predicted proportion of respondents in each PHQ-9 change category, for each number of deployment exposures. * Note this plot is computed at the average level of Age (31.12) and the reference level for gender (Male), service (Army) and rank (Other Ranks).

6.3.5 Traumatic Deployment Experiences

The percentage of respondents in each PHQ-9 change category, who had indicated at least one exposure to each of the nine categories of deployment experiences (n = 1194) is summarised in Table 6.8. Note that each respondent could have responded positively to more than one item.

Deployment experiences	Exposed			Unexposed						
	Yes N	Percentage	PHQ-9 Increase	PHQ-9 Decrease	PHQ-9 No change	No N	Percentage	PHQ-9 Increase	PHQ-9 Decrease	PHQ-9 No change
Coming under fire	870	72.9%	16.3%	3.4%	80.3%	323	27.1%	13.6%	5.9%	80.5%
Vulnerable situations or fear of events	833	69.8%	17.2%	3.6%	79.2%	361	30.2%	11.9%	5.0%	83.1%
Casualties among those close to you	723	60.8%	17.4%	3.3%	79.3%	466	39.2%	12.2%	5.2%	82.6%
In danger of being killed/injured	574	48.2%	17.1%	2.8%	80.1%	616	51.8%	14.0%	5.2%	80.8%
Seeing/handling dead bodies	580	48.8%	17.2%	4.0%	78.8%	608	51.2%	13.7%	4.1%	82.2%
Discharging own weapon	319	26.8%	15.4%	2.8%	81.8%	872	73.2%%	15.6%	4.4%	81.0%
Unable to respond to a threatening situation	242	20.4%	20.7%	4.1%	75.2%	946	79.6%	20.7%	4.1%	75.2%
Human degradation	154	13.0%	27.3%	3.3%	69.4%	1032	87.0%	27.2%	3.3%	69.5%
Actions resulting in injury or death	91	7.7%	18.7%	5.5%	75.8%	1098	92.3%	15.1%	3.9%	81.0%

Coming under fire, exposure to vulnerable situations or fear of events and casualties among those close to you were the most common deployment experiences reported by respondents.

Using 'No exposure' as the predictor reference, and 'No change' as the outcome reference, again while most participants did not change in PHQ-9 depression severity between pre- and post-deployment, participants exposed to vulnerable situations or fear of events (p=0.003, OR=2.08, 95%CI 1.27, 3.41), being unable to respond to a threatening situation (p=0.002, OR=1.84, 95%CI 1.24, 2.74), or human degradation (p<0.0001, OR=2.67, 95%CI 1.75, 4.07), were all more likely to increase in PHQ-9 category compared to those who were not exposed.

6.3.6 Total Time on Prior Deployments

Table 6.9 (Appendix M) shows the percentage of participants in each PHQ-9 change category for the different 'Time away on prior deployment' categories (n = 893). Using 'None' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between time away on prior deployments and PHQ-9 change.

6.3.7 Number of Prior Deployments

Table 6.10 (Appendix M) presents the percentage of participants in each PHQ-9 change category for the different 'Number of prior deployment' categories (n = 1103). Using 'None' as the predictor reference and 'No change' as the outcome reference, there was no significant association between the number of prior deployments and PHQ-9 change.

6.3.8 Previous Combat Exposure

Table 6.11 (Appendix M) shows the percentage of participants in each PHQ-9 change category for those with and without previous combat exposure (n = 1183). Using 'no change' as the outcome reference, there was no significant association between previous combat exposure and PHQ-9 change.

6.4 Summary of Results

Table 6.12 summarises the key findings presented in this results section in relation to the questions posed in section 6.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Length of most recent deployment	Nil
Q2. Role on most recent deployment	A greater proportion of participants in a combat role or who worked outside the main support base increased in PHQ-9 between pre- and post-deployment, compared to those who were in non-combat roles outside Afghanistan
Q3a. Number of traumatic deployment exposures	Those participants who had the highest number of deployment exposures were more likely to increase in PHQ-9 compared to those who had the lowest number of deployment exposures.

Q3b. Traumatic deployment experiences	Participants exposed to vulnerable situations or fear of events, being unable to respond to a threatening situation, or human degradation, were all more likely to increase in PHQ-9 category compared to those who were not exposed.
Q4. Total time on	Nil
prior deployments	
Q5. Number of prior	Nil
deployments	
Q6. Previous	Nil
combat exposure	

6.5 Discussion

For respondents who completed the PHQ-9 at both pre- and post-deployment, the vast majority had minimal to mild depressive symptoms at pre- and post-deployment, and 80.1% (n = 969) of respondents did not change PHQ-9 bands. However, for 15.8% (n = 191) of respondents the severity of depressive symptoms did increase between pre- and post-deployment. These data present the PHQ-9 scores from a dimensional perspective, and do not use the cut off to reflect the presence of probable major depressive disorder. In other words, they provide an indication of the severity of depressive symptoms, and it is this which is discussed in the following section.

Contrary to what would be expected based on previous research findings [14], there were no effects of deployment or previous combat exposure on change in depressive symptoms. This finding is in line with results from the ADF Mental Health Prevalence and Wellbeing Study [5], which found no significant differences in depression between participants who had deployed and those who had never deployed. A number of other studies have also found that depression could *reduce* following deployment. For example, MacGregor et al [23] found depressions rates were lower among US military personnel deployed to Iraq two or more times. Similarly, Adler et al. [24] found that for male US military personnel deployment. These findings may reflect the fact that only the more resilient deploy on multiple occasions, suggesting that a healthy soldier effect could account for the lower rates of depression. However, combat [16] and trauma exposure [25] have both been posited as explanations for the effects of deployment on mental health outcomes, as explained below.

6.5.1 Role on Recent Deployment

While findings regarding the effects of deployment on depressive symptoms have been somewhat mixed, combat exposure has quite reliably been found to be associated with increased mental health problems [16, 26], and combat stress in general appears to be directly related to symptoms of depression. In the current study, being in a combat role or working outside of the main support base on the most recent deployment were associated with increased depressive symptoms. People who were in these roles versus those in non-combat roles were at a significantly greater risk of having an increase in depressive symptoms between preand post-deployment. Wells et al [16] proposed that changes in depression attributed to deployment could be explained by level of combat exposure. This hypothesis is further supported by a study comparing mental health outcomes for US personnel deploying to Iraq or Afghanistan. This study found that among troops deployed to Iraq, greater rates of combat exposure were associated with higher rates of depressive symptoms as measured by the PHQ-9 [25]. Findings that more deployments in general can reduce the likelihood of having depressive symptoms, while specific exposures related to a combat role increase the risk of depression, also support this argument [23].

6.5.2 Traumatic Deployment Experiences

A number of studies have proposed that traumatic exposures while on deployment (especially in combat roles) may impact on the mental health of serving personnel. In the current study, both the total number, as well as specific types of traumatic deployment exposures had an effect on the change in depressive symptoms between pre- and post-deployment. Compared to those personnel who had the lowest number of traumatic exposures while on deployment, those with the highest number were significantly more likely to have an increase in depressive symptoms. A retrospective study of Dutch military personnel deployed to Afghanistan, also found an association between the number of stressors experienced while on deployment and post-deployment depressive symptoms [17].

Research suggests that in addition to traumatic exposures having a cumulative impact on depressive symptoms, specific types of trauma may be particularly important. In the current study, the most common deployment experiences reported by respondents included 'coming under fire', 'exposure to vulnerable situations' or 'fear of events', and 'casualties among those close to you'. However, the experiences most likely to be associated with increased depressive symptoms were 'being in a vulnerable situation' or 'fear of events', 'being unable to respond to a threatening situation', and in line with the findings from Sareen et al [18], 'experiencing human degradation'.

The MEAO Census Study [27] also found that responders who reported specific types of traumatic deployment exposures were significantly more likely to meet criteria for a major depressive syndrome. These traumatic deployment exposures were handling or seeing dead bodies, being in a threatening situation and unable to respond and witnessing human degradation and misery. Other studies have found that witnessing atrocities [18], perceived danger, and exposure to death and dying [19] can predict increased depressive symptoms.

6.6 Summary

Consistent with the previous chapter on psychological distress, this study has shown that operating in a combat role or outside of the main support base was associated with an increase in depressive symptoms between pre- and post-deployment. In addition, this study found that increases in depressive symptoms were associated with the number and type of traumatic deployment exposures. However, while the severity of depressive symptoms for 15.8% of respondents (n = 191) did increase between pre- and post-deployment, 80.1% (n = 969) stayed the same and a further 4.1% (n = 49) experienced a decrease in the severity of their depressive symptoms. Importantly, there was also a small group (2.1%) who had moderate or severe depressive symptoms at post-deployment. Once again, further research is required to identify if these changes are suggestive of a longer term trend, or alternatively whether these symptoms will stabilise over time.

The next chapter focuses on **PTSD symptoms** (Chapter Seven). Once again, after providing a short introduction, an explanation of the primary measure/s is provided before presenting the results. The chapter again concludes with a discussion of these results in relation to the current literature. Further chapters included within Section Two are:

- Chapter Eight Alcohol Misuse
- Chapter Nine Co-Morbidity and Associations

Following sections of this report focus on other health outcomes of interest.

- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- Conclusions and Limitations are presented in Chapter Twenty Two

6.7 Other Chapters of Relevance

• Chapter Nine – Psychological Co-Morbidity at Post-Deployment

6.8 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

- Is there an interaction between the various deployment-related factors, age and prior exposures, on depressive symptoms?
- What factors are associated with different trajectories of depressive symptoms (decreasing, stable and increasing symptoms)?
- What is the impact of the pre-deployment symptom interpretation questionnaire, on the pattern of depression symptom reporting?
- Is there a hierarchy of depressive symptoms that emerges in the post-deployment environment?

6.9 References

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Chapter Seven – PTSD Symptoms and Other Anxiety Syndromes

Key Points

- 1. Just over **88% of participants scored below the ADF cut-off** for PTSD symptoms at post-deployment, as measured by the PCL-C.
- 2. There was a **statistically significant increase** in PTSD symptoms between pre- and post-deployment.
- 3. This increase was significantly associated with several factors connected to the **most recent deployment**.
- 4. Specifically, these **significant associations** were between increased PTSD symptoms and:
 - a longer deployment period (6 to 7 months, 8 months or 9 to 12 months),
 - being in a combat role or operating outside of the main support base,
 - reporting any of the traumatic deployment experiences; and
 - reporting a very high number (>35) of deployment exposures.
- 5. No significant associations were found between increases in PTSD symptoms between pre- and post-deployment, and factors associated with prior deployments.
- 6. The findings in this chapter also show that the majority of participants did not meet criteria for other anxiety disorders at either pre- or post-deployment.

This chapter presents and discusses the findings relating to changes to PTSD symptoms between pre- and post-deployment. The chapter begins by briefly discussing current literature pertaining to PTSD and PTSD symptoms. Results are then provided, beginning with a comparison of the mean pre-deployment PTSD symptom scores, between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. All subsequent analyses within the result sections include only those participants who completed both the pre- and post-deployment measure. All subsequent analyses within the result sections include only those participants who completed both the pre- and post-deployment measures. The chapter concludes by discussing the primary findings pertaining to PTSD symptoms. Other chapters which also present findings pertinent to the focus of this chapter include Chapter Nine (Psychological Co-morbidity), Chapter Eleven (mTBI), Chapter Seventeen (Personal Relationships), Chapter Eighteen (Relationships with Children) and Chapter Twenty One (Allostatic Load).

7.1 Introduction

While the psychological burden of war has long been recognised, PTSD was only included in DSM III in 1980 [1]. Before this, shell shock and other reactions to combat stress were all labelled as traumatic neurosis [2]. This has meant that prior to the publication of DSM III, there was a dispute about whether traumatic neurosis was distinct from anxiety and depressive disorders. The drafting of DSM III was a watershed moment, in that it formalised the criteria for PTSD.

Recent studies have found that rather than being a single, clearly diagnosable disorder, a range of PTSD subtypes exist, including those referred to as acute, chronic, delayed onset and sub-syndromal. In particular, traumatic exposures in military populations have been found to be associated with a greater proportion of delayed onset PTSD [3]. For example, a meta analysis of delayed onset PTSD [4] reviewed longitudinal studies with a mean interval of 25 months and a maximum range of 60 months. In the combined study population, 24.8% (95% CI=22.6% to 27.2%) had delayed onset PTSD.

Despite this recent recognition of subtypes including delayed onset and subsyndromal PTSD, the majority of military and community studies have tended to focus on symptoms suggestive of a PTSD diagnosis. The Australian National Survey of Mental Health [5], for example, estimated life-time prevalence rates of PTSD to be 12.2%, and 12 month prevalence rates to be 6.4%. In relation to military populations, the 2010 ADF Mental Health Prevalence and Wellbeing Study found that approximately 8.3% of the entire ADF (deployed and non-deployed) met the criteria for a PTSD diagnosis in the previous 12 months [6]. A US study [7] found that approximately 5% to 6% of military personnel reported symptoms consistent with a diagnosis of PTSD in the past 30 days, while a much lower prevalence rate of between 2.4% and 2.7% has been reported for UK military personnel over the same time period [8].

Differences in the prevalence of PTSD symptoms may also be associated with sex, service and service type. McFarlane et al. [6] found a significant sex by service interaction, whereby males in the Army and Navy reported significantly higher PCL scores than males in the Air Force. Within the Air Force, however, females reported significantly higher scores than males. Maguen et al. [9] also found a stronger association between injury and PTSD symptoms for females compared to males. Between-service differences in the prevalence of PTSD symptoms have also been found. Sundin et al. [10] reported lower rates of PTSD among UK commandos compared to infantry personnel. Similarly, Eisen et al [11] found significantly more PTSD diagnoses for US Army and Marine groups, compared to Air Force veterans.

Deployments to Afghanistan and Iraq, and combat exposure in particular, have been shown to be associated with PTSD symptoms [12, 13], with repeated and/or lengthy deployments a particular risk factor for the development of PTSD post-deployment [14, 15]. Hoge et al. [16] reported a positive linear relationship between the prevalence of PTSD and the number of fire-fights soldiers experienced. Studies of Vietnam [17], Gulf War 1990-91 [18], and Iraq war [19] veterans have all demonstrated that direct combat exposure, and specifically the act of killing, are significantly associated with increased rates of PTSD together with increased anger, violence and antisocial behaviours. In addition, studies have demonstrated that lifetime trauma exposures (including childhood abuse) have a cumulative effect on the risk of developing post-deployment PTSD [20, 21].

7.2 Methods

The primary outcome of interest in this chapter is PTSD symptoms, measured by the Posttraumatic Stress Disorder Checklist (PCL) [22] at both pre- and post-deployment within the self report questionnaire. While there are a number of versions of the PCL, this study used the PCL Civilian (PCL-C) which is not linked to a specific event, and is currently used by the ADF in post-operational screening.

In accordance with the ADF post-operational screening [23], a total score for the PCL-C was computed by adding together the responses for the 17 items, with the total score ranging from 17 to 85. Severity categories were then determined, with scores from 17 to 29 considered to be **low**, 30 to 39 **medium**, 40 to 49 **high** and 50+ **very high**.

In addition, the chapter will present descriptive tables for panic attack, panic syndrome and general anxiety syndrome, all of which were measured by the PHQ-15 anxiety module (see Appendix C) at both pre- and post-deployment within the self report questionnaire. In order to meet criteria for a **panic attack**, respondents must have had an anxiety attack in the last four weeks and have experienced four of the specified symptoms including feeling short of breath, heart racing, chest pains and sweating etc. To meet the criteria for **panic syndrome**, the respondent must also have experienced a previous panic attack, reported that these panic attacks were without obvious precipitant, and be preoccupied about having another panic attack.

A positive screen for **general anxiety syndrome**¹ required respondents to have felt nervous, anxious, on edge, or worrying a lot about different things, and three or more other symptoms including feeling restless, getting tired easily, trouble concentrating, and becoming easily annoyed or irritable, more than half the time during the previous four weeks [24]. Meeting the criteria for panic attack, panic syndrome, and/or general anxiety syndrome in this study does not necessarily equate to a DSM IV disorder.

7.2.1 Questions to be Addressed

Only PTSD symptoms measured by the PCL-C will be used in the analysis of the following questions. The questions examined in this chapter, which were informed by the literature review include:

- 1. Is there an association between **length of most recent deployment** and a change in PCL-C scores from pre- to post-deployment?
- 2. Is there an association between **role on most recent deployment** and changes in PCL-C scores from pre- to post-deployment?
- 3. Is there an association between the number and type of **traumatic deployment experiences on most recent deployment**, and change in PCL-C scores from pre- to post-deployment?
- 4. Is there an association between **total length of time spent on deployment** in the previous three years and a change in PCL-C scores from pre- to post-deployment?
- 5. Is there an association between the **number of previous deployments** and a change in PCL-C scores from pre- to post-deployment?

¹ The screen for 'general anxiety syndrome' in the PHQ-15 utilises DSM IV criteria for GAD, and as such, acts as a yes/no screen (but not a diagnosis) for GAD. The GAD-7 is an additional module that allows measurement of GAD severity, but has not been utilised here.

6. Is previous **combat exposure** associated with changes in PCL-C scores from pre- to post-deployment?

7.2.2 Sample Sizes

This section provides information about the sample size for each of the anxiety measures considered within this chapter. Sample sizes vary between measures as not all respondents completed every question.

7.2.2.1 Sample Size for PCL-C Analyses

The total sample size used **to identify change between pre- and post-deployment PCL-C scores** was 1,231. Of the 1,324 participants who completed a pre- and a post-deployment questionnaire 93 were excluded - 30 participants did not complete the PCL-C measure at pre-deployment, 60 did not complete the PCL-C at postdeployment, and three participants did not complete the PCL-C at either pre- or postdeployment.

The total sample size used **to compare the mean pre-deployment PCL-C scores** for pre-deployment only participants, with pre- and post-deployment participants, was 526. Of the 547 participants who completed a pre-deployment questionnaire only, 21 participants did not complete the PCL-C measure at pre-deployment.

There may also be some variation to the sample sizes used for specific analyses due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

7.2.2.2 Sample Size for Panic Attack and Panic Syndrome Descriptive Tables The total sample size used **to identify change between pre- and post-deployment PHQ-15 scores (panic attack and panic syndrome)** was 1,237. Of the 1,324 participants who completed a pre- and a post-deployment questionnaire, 26 participants did not complete the PHQ-15 measure at pre-deployment, 59 did not complete the PHQ-15 at post-deployment, and three participants did not complete the PHQ-15 at either pre- or post-deployment.

The total sample size used to compare the mean pre-deployment PHQ-15 scores (panic attack and panic syndrome) for pre-deployment only participants, with preand post-deployment participants, was 525. Of the 547 participants who completed a pre-deployment questionnaire only, 22 participants did not complete the PHQ-15 measure at pre-deployment.

7.2.2.3 Sample Size for General Anxiety Syndrome Descriptive Tables

The total sample size used **to identify change between pre- and post-deployment PHQ-15 (General Anxiety Syndrome)** was 1,216. Of the 1,324 participants who completed a pre- and a post-deployment questionnaire, 41 participants did not complete the PHQ-15 measure for General Anxiety Syndrome at pre-deployment, 65 did not complete the PHQ-15 measure for General Anxiety Syndrome at postdeployment, and two participants did not complete the PHQ-15 measure for General Anxiety Syndrome at either pre- or post-deployment.

The total sample size used to compare the mean pre-deployment PHQ-15 scores (General Anxiety Syndrome) for pre-deployment only participants, with pre- and post-deployment participants was 520. Of the 547 participants who completed a pre-deployment questionnaire only, 27 participants did not complete the PHQ-15 measure for General Anxiety Syndrome at pre-deployment.

Due to the small number of respondents who met the criteria consistent with panic attack, panic syndrome or general anxiety syndrome, and the small number of
respondents who changed between pre- and post-deployment only descriptive tables will be provided within this chapter. No further analysis for panic attack, panic syndrome or general anxiety syndrome will be presented.

7.2.3 Data Analysis

Two analysis strategies were used in the following chapter. First, a mixed model for repeated measures was used to analyse continuous PCL-C scores. This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post) and their interaction(s) are included as fixed effects in the model.

Second, scores on the PCL-C were categorised into 4 severity bands (Low, Moderate, High, Very High) at pre-deployment and post-deployment. Stepwise change across bands (1 step, 2 step, 3 step) between pre- and post-deployment was then calculated for each participant. For the purposes of modelling, these changes were then simplified into three change categories ('Increase', 'Decrease' or 'No change'). Due to the small number of participants who decreased, these were combined with 'No change'. The change categories were then used as a two level categorical outcome in a binary logit model. This approach allowed for the shift in severity of symptoms between the two time points to be examined. In all models the default outcome reference category was 'decrease/no change'.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

7.3 Results

Descriptive tables for panic attack, panic syndrome and general anxiety syndrome, are discussed below and presented in Appendix N. Due to the small number of responders who met criteria at either pre- and/or post-deployment, and the small number of responders who changed between pre- and post-deployment for these measures, no further analyses were conducted, and panic attack, panic syndrome and general anxiety syndrome will not be discussed further in this chapter.

The primary focus of this chapter is PTSD symptoms. In addition to presenting the descriptive tables, this result section also presents the analyses pertaining to the questions of interest in relation to changes in PCL-C scores (see above section 7.2.3)

7.3.1 Descriptive Tables for Panic Attack, Panic Syndrome and General Anxiety Syndrome

7.3.1.1 Panic Attack

Analyses of the data relevant to panic attack found that more pre-deployment only respondents met the criteria for panic attack, compared to those respondents who

completed both a pre- and post-deployment survey (0.8% versus 0.4%, respectively) (Table 7.1 Appendix N). For respondents who completed PHQ-15 at both pre- and post-deployment, the vast majority (99.6%) did not meet the criteria for panic attack at pre-deployment. Importantly only 3.0% of respondents met the criteria for panic attacks at post-deployment only (Table 7.2, Appendix N).

7.3.1.2 Panic Syndrome

Analyses of the data relevant to panic syndrome found that there were 0.2% more pre-deployment only respondents who met the criteria for panic syndrome, compared to those respondents who completed both a pre- and post-deployment survey (Table 7.3, Appendix N). For respondents who completed PHQ-15 at both pre- and post-deployment, the vast majority (99.8%) did not meet the criteria for panic syndrome at pre-deployment. Importantly, just 0.9% of the pre- and post-deployment responders met the criteria for panic syndrome at post-deployment only (Table 7.4, Appendix N).

7.3.1.3 General Anxiety Syndrome

Analyses of the data relevant to general anxiety syndrome found that there were 1% fewer pre-deployment only responders who met the criteria for general anxiety syndrome, compared to those respondents who completed both a pre- and post-deployment survey (see Table 7.5, Appendix N). For respondents who completed PHQ-15 at both pre- and post-deployment, the vast majority (99.4%) did not meet the criteria for general anxiety syndrome at pre-deployment. Importantly, just 1.6% of the pre- and post-deployment responders met the criteria for general anxiety syndrome at post-deployment of the pre- and post-deployment responders met the criteria for general anxiety syndrome at post-deployment only (Table 7.6, Appendix N).

7.3.2 Descriptive Tables for PTSD Symptoms

An analyses of the data relevant to PTSD symptoms found that the mean PCL-C scores at pre-deployment were not significantly different (p=0.09) between responders who only completed a pre-deployment survey and those who completed both a pre- and post-deployment survey (Table 7.7, Appendix N). For respondents who completed PCL-C at both pre- and post-deployment, the mean PCL-C scores were 19.6 and 22.1 respectively (difference = 2.5, 95% CI 2.1, 2.9), and this change was statistically significant (p<0.0001). The distribution of mean change between pre- and post-deployment is depicted in Figure 7.1 (See Table 7.8, Appendix N).



Figure 7.1: Distribution of mean PCL-C change scores between pre- and post-deployment.

The number and percentage of pre- and post-deployment responders in each PCL-C risk category (low = 17-29; moderate = 30-39; High = 40-49; Very High = 50-85) is presented in Table 7.9.

PCL- C			Total N			
		Low N(%)	Moderate N(%)	High N(%)	Very High N(%)	
Pre	Low	1067 (86.6%)	68 (5.5%)	18 (1.5%)	18 (1.5%)	1171
	Moderate	18 (1.4%)	20 (1.6%)	6 (0.5%)	5 (0.4%)	49
	High	1 (0.1%)	1 (0.1%)	4 (0.3%)	3 (0.3%)	9
	Very High	0 (0.0%)	0 (0.0%)	1 (0.1%)	1 (0.1%)	2
Т	otal N	1086	89	29	27	1231

Table :	7.9: Change in	PCL-C risk	category	between	pre- and	post-deplo	ovment
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Table 7.10 (Appendix N), presents the percentage of pre- and post-deployment responders in each PCL-C category for each subgroup, while Table 7.11 (Appendix N) presents the change in PCL-C categories between pre- and post-deployment for these responders. Of pre- and post-deployment responders, 88.7% (n = 1,092) did not change PCL-C risk categories between pre- and post-deployment. However, 9.6% (n = 118) of respondents increased at least one category (either low to moderate, moderate to high or high to very high), while 1.7% (n = 21) of respondents decreased at least one category.

Table 7.12 presents the change according to the epidemiological cut-offs developed by the 2010 Mental Health and Wellbeing Survey [25]. These cut-offs are designed to

bring the number of false positives and false negatives closest together and therefore is the closest estimate to the true prevalence of any 30-day ICD-10 PTSD.

Table 7.12: Change in PCL-C using epidemiological cut-offs developed by the 2010 Mental Health
and Wellbeing Survey between pre- and post-deployment

PCL-C		I	Total N	
		Below epi- cut-off	Above epi- cut-off (≥53)	
Pre	Below epi-cutoff	1208 (98.1%)	22 (1.8%)	1230
	Above epi-cutoff (≥53)	0	1 (0.1%)	1
	Total N	1208	23	1231

Of most interest in this table, is the number of participants who met the epidemiological cut-off at post-deployment (n=23).

7.3.3 Associations with Changes in PCL-C Scores

7.3.4 Length of Recent Deployment

The mean changes to PCL-C scores between pre- and post-deployment for the different 'length of recent deployment' categories are presented in Table 7.13

Length of most recent deployment (months)	N	Pre-deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% CI)
≤5 months	383	19.94	21.28	1.34
		(19.28, 20.61)	(20.34, 22.22)	(0.62, 2.05)
6 or 7 months	369	19.88	22.98	3.10
		(19.13, 20.62)	(21.97, 23.98)	(2.37, 3.83)
8 months	268	19.44	21.93	2.49
		(18.60, 20.29)	(20.77, 23.09)	(1.63, 3.34)
9-12 months	211	19.39	22.97	3.58
		(18.50, 20.27)	(21.71, 24.23)	(2.62, 4.55)

 Table 7.13: Mean (95% CI) PCL-C change for each length of recent deployment.

As can be seen from Table 7.13, the increase in PCL-C scores between pre- and post-deployment for those who were away on deployment for ≤ 5 months was significantly less, on average, than for those who were away for 6 or 7 months (p=0.0007), 8 months (p=0.04) and 9-12 months (p=0.0003) (see figure 7.2).



Figure 7.2: Mean PCL-C change for each length of recent deployment.

An analysis of the percentage of participants in each PCL-C change category (Increase, Decrease, No change) for the different 'Length of recent deployment' categories was also conducted (Table 7.14, Appendix N). Using '<=5 Months' as the predictor reference, and 'No change/Decrease' as the outcome reference, there was no significant association between the length of recent deployment and PCL-C change.

7.3.5 Role on Recent Deployment

The mean changes to PCL-C scores between pre- and post-deployment for the different roles on recent deployment are presented in Table 7.15.

Role on recent deployment	N	Pre- deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% CI)
Combat Afghan &	632	20.15	23.97	3.82
Outside MSB		(19.23, 21.08)	(22.91, 25.02)	(3.26, 4.36)
Inside MSB	284	19.95	21.91	1.96
		(19.09, 20.82)	(20.76 <i>,</i> 23.06)	(1.14, 2.78)
Outside Afghan	315	19.75	20.11	0.36
		(19.04, 20.45)	(19.10, 21.12)	(-0.12, 1.14)

 Table 7.15: Mean (95% CI) PCL-C change for each role on recent deployment.

As can be seen in Table 7.15, the increase in PCL-C scores between pre- and postdeployment, was significantly greater, on average, for those whose role was Combat



Afghan or Outside MSB compared to those whose role was Inside MSB (p=0.0002) and Outside Afghan (p<0.0001) (see Figure 7.3).

Figure 7.3: Mean PCL-C change for each role on recent deployment.

An analysis of the percentage of participants in each PCL-C change category for the different 'Role on most recent deployment' categories was also conducted (Table 7.16).

Table 7.16: Percentage of participants in each PCL-C change category, for each role on recen	t
deployment.	

Role on recent deployment	N	PCL-C	PCL-C No
		Increase	change/Decrease
Combat Afghan & Outside MSB	632	13.0%	87.0%
Inside MSB	284	6.7%	93.3%
Outside Afghan	315	5.4%	94.6%

Using 'Outside Afghan' as the predictor reference, and 'No change/Decrease' as the outcome reference, there was a significant association between role on most recent deployment and PCL-C category change (p=0.01, OR = 2.87, 95% CI 1.23, 6.70). Those respondents who were in a combat role or who worked outside of the main support base were significantly more likely to have an increase in PCL-C scores between pre- and post-deployment, compared to those respondents who had a role based outside of Afghanistan. This is illustrated in Figure 7.4.





7.3.6 Number of Traumatic Deployment Exposures

The mean changes to PCL-C scores between pre- and post-deployment for the different 'number of deployment exposure' categories (n = 1205) are presented in Table 7.17.

Deployment exposure (category)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
Low	346	19.76	20.04	0.28
		(19.09, 20.44)	(19.09, 20.99)	(-0.45, 1.01)
Medium	264	20.02	21.96	1.94
		(19.17 <i>,</i> 20.87)	(20.81, 23.10)	(1.11, 2.77)
High	294	19.80	22.54	2.74
		(18.82, 20.77)	(21.32, 23.75)	(1.95, 3.53)
Very High	301	20.79	25.77	4.98
		(19.78, 21.80)	(24.54, 27.01)	(4.21, 5.76)

Table 7.17:	: Mean (95% Cl	PCL-C change for	or each number	of deployment	exposures.
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As can be seen in Table 7.17, the increase in PCL-C scores between pre- and postdeployment was significantly different between the four categories of deployment exposure (p<0.0001). This difference is most likely due to the Very High category, which showed the greatest increase in PCL-C scores between pre- and postdeployment compared to all other categories (see Figure 7.5).



Figure 7.5: Mean PCL-C change for each number of deployment exposures.

The percentage of participants in each PCL-C change category for the different 'number of deployment exposure' categories are presented in Table 7.18.

Table 7.18: Percentage of participants in each PCL-C change category for each number o	f
deployment exposures.	

Deployment	N	PCL-C	PCL-C
exposure (category)		Increase	No change/ Decrease
Low	346	4.6%	95.4%
Medium	264	8.7%	91.3%
High	294	7.8%	92.2%
Very High	301	16.9%	83.1%

Using 'low exposures' as the predictor reference, and no change/decrease as the outcome reference, there was also a significant association between the number of deployment exposures and PCL-C category change. Those respondents who reported a very high number of deployment exposures were significantly more likely to increase in PCL-C scores between pre- and post-deployment compared to those who reported the lowest number of deployment exposures (p=0.0001, OR=5.45, 95%CI 2.28, 13.03). The association is illustrated in Figure 7.6.



Figure 7.6: Percentage of respondents with increasing PCL-C for each number of deployment exposures

7.3.7 Traumatic Deployment Experiences

The percentage of respondents who had indicated at least one exposure to each of the nine deployment experience categories is summarised in Table 7.19, along with associated change in PCL-C scores between pre- and post-deployment. Note that each respondent could have responded positively to more than one item.

Deployment	Ex	posed	Unexposed			
Experiences	Number Change PCL-C Number (%) Scores (%) (95% Cl)		Number (%)	Change PCL-C Scores (95% CI)		
Coming under fire	879	3.21	325	0.27		
	(73.0%)	(2.75, 3.68)	(27.0%)	(-0.49, 1.03)		
Vulnerable situations or fear of events	841	3.33	364	0.31		
	(69.8%)	(2.86, 3.80)	(30.2%)	(-0.40, 1.03)		
Casualties among those close to you	731	3.62	468	0.52		
	(61.0%)	(3.12, 4.13)	(39.0%)	(-0.11, 1.14)		
Seeing/handling dead	587	3.86	611	1.02		
bodies	(49.0%)	(3.29, 4.42)	(51.0%)	(0.47, 1.58)		
In danger of being	578	3.89	622	1.05		
killed/injured	(48.2%)	(3.32, 4.46)	(51.8%)	(0.50, 1.60)		
Discharging own	325	4.23	877	1.74		
weapon	(27.0%)	(3.47, 4.99)	(73.0%)	(1.28, 2.20)		
Unable to respond to a threatening situation	243 (20.3%)	5.20 (4.32, 6.08)	955 (79.7%)	1.72 (1.27, 2.16)		
Human degradation	159	6.08	1037	1.83		
	(13.3%)	(5.00, 7.16)	(86.7%)	(1.40, 2.25)		
Actions resulting in	91 (7.6%)	5.52	1108	2.15		
injury or death		(4.07, 6.97)	(92.4%)	(1.74, 2.57)		

Table 7.19: Mean (95% CI) PCL-C change for each deployment experience.

For all nine categories, the change in PCL-C score between pre- and postdeployment was significantly greater (p<0.0001) for those exposed compared to not exposed to the deployment experience.

The percentage of respondents in each PCL-C change category, who had indicated at least one exposure to each of the nine categories of deployment experiences is summarised in Table 7.20.

Deployment experiences		Ехро	osed			Unex	posed		Exposed Vs	Unexposed
	Yes N	Percentage	PCL-C Increase	PCL-C No change/ Decrease	No N	Percentage	PCL-C Increase	PCL-C No change/ Decrease	OR (95% CI)	Ρ
Coming under fire	879	73.0%	11.0%	89.0%	325	27.0%	4.9%	95.1%	2.17 (1.11, 4.25)	p=0.02
Vulnerable situations or fear of events	841	69.8%	11.3%	88.7%	364	30.2%	4.9%	95.1%	2.12 (1.02, 4.42)	p=0.04
Casualties among those close to you	731	61.0%	12.6%	87.4%	468	39.0%	4.3%	95.7%	3.04 (1.68, 5.51)	p=0.0002
In danger of being killed/injured	578	48.2%	12.6%	87.4%	622	51.8%	6.4%	93.6%	1.97 (1.21, 3.20)	p=0.006
Seeing/handling dead bodies	587	49.0%	13.6%	86.4%	611	51.0%	5.2%	94.8%	2.93 (1.79, 4.80)	p<0.0001
Discharging own weapon	325	27.0%	14.2%	85.8%	877	73.0%	7.5%	92.5%	1.83 (1.15, 2.91)	p=0.01
Unable to respond to a threatening situation	243	20.3%	17.7%	82.3%	955	79.7%	7.3%	92.7%	2.56 (1.64, 4.01)	p<0.0001
Human degradation	159	13.3%	20.1%	79.9%	1037	86.7%	7.6%	92.4%	2.84 (1.78, 4.54)	p<0.0001
Actions resulting in injury or death	91	7.6%	18.7%	81.3%	1108	92.4%	8.6%	91.4%	2.31 (1.29, 4.14)	p=0.005

 Table 7.20: Percentage of respondents exposed to each experience, in each PCL-C change category.

Using 'No change/Decrease' as the outcome reference, respondents who reported exposure to any of the experiences were more likely to have an increase in PCL-C scores compared to those participants who were not exposed. Odds ratios are presented in Table 7.20.

7.3.8 Total Time on Deployment in Previous Three Years

The mean changes to PCL-C scores between pre- and post-deployment for the different 'time away on prior deployment' categories (n = 914) are presented in Table 7.21 (Appendix N). As can be seen from this table, time away on prior deployments was not significantly associated with the increase in PCL-C scores between pre- and post-deployment.

An analysis of the percentage of participants in each PCL-C change category for the different 'Total time on prior deployment' categories, was also conducted (Table 7.22, Appendix N). Using 'None' as the predictor reference, and 'No change/Decrease' as the outcome reference, there was no significant association between the time spent on deployment over the last three years and PCL-C change.

7.3.9 Number of Prior Deployments

The mean changes to PCL-C scores between pre- and post-deployment for the different 'number of prior deployment' categories (n = 1124) are presented in Table 7.23 (Appendix N). The increase in PCL-C scores between pre- and post-deployment was not significantly different between the four number of prior deployment categories.

An analysis of the percentage of participants in each PCL-C change category for the different 'Number of prior deployment' categories, was also conducted (Table 7.24, Appendix N). Using 'None' as the predictor reference and 'No change/Decrease' as the outcome reference, there was no significant association between the number of prior deployments and PCL-C change.

7.3.10 Previous Combat Exposure

The mean changes to PCL-C scores for those with and without previous combat exposure (n = 1219) are presented in Table 7.25 (Appendix N). There was no significant association between prior combat exposure and changes in PCL-C scores.

An analysis of the percentage of participants in each PCL-C change category for participants with and without previous combat exposure was also completed (Table 7.26, Appendix N). There was no significant association between previous combat exposure and PCL-C change.

7.4 Summary of Results

Table 7.27 summarises the key findings presented in this results section in relation to the questions posed in section 7.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Length of most recent deployment	Compared to those away for ≤ 5 months, those away for 6 to 7 months, 8 months and 9 to 12 months had a significantly greater increase in PCL-C scores between pre- and post-deployment.
Q2. Role on most recent deployment	The increase in mean PCL-C scores between pre- and post- deployment was greater for those in a combat role or who operated outside a main support base, than for those whose role was inside a main support base and those who were Outside Afghan.
Q3a. Number of traumatic deployment	Those participants who had a Very High number of traumatic deployment exposures showed the greatest increase in PCL-C scores between pre- and post-deployment.
exposures	The proportion of participants' whose PCL-C scores increased was greater for those with higher numbers of deployment exposures.
Q3b. Traumatic deployment experiences	For all nine deployment experiences, the change in PCL-C score between pre- and post-deployment was significantly greater for those exposed compared to not exposed.
	The proportion of participants whose PCL-C scores increased was greater for those who reported exposure to any of the experiences compared to those participants who were not exposed.
Q4. Total time on prior deployments	Nil
Q5. Number of prior deployments	Nil
Q6. Previous combat exposure	Nil

Table 7.27: Summary of key findings presented in this chapter

7.5 Discussion

The mean PCL-C scores for participants who provided data on this measure at both pre- and post-deployment was 19.6 and 22.1 respectively, and this change was statistically significant. Both of these mean PCL-C scores were, however, lower than the mean score reported by the 2010 ADF Mental Health Prevalence and Wellbeing Study [6] (22.7, CI 22.6, 22.8).

Likewise, the percentage of participants who fell into the very high PCL-C category at pre- (0.2%) and post-deployment (2.4%) for the MEAO Prospective Study was lower than that reported by the ADF Mental Health Prevalence and Wellbeing Study (3%). In comparison, the MEAO Census Study [26] found that only 1.7% of currently serving regular ADF members who last deployed to the MEAO not more than one year prior to completing their questionnaire, fell into the very high PTSD symptom band. However, the percentage among respondents who had deployed to the MEAO between two and three years prior to completing the questionnaire was higher (3.2%).

It is important to note that prevalence rates between studies are not always directly comparable for two reasons. First, there are a number of ways in which studies measure PTSD. For example, the 2010 ADF Mental Health Prevalence and Wellbeing Study [25] measured prevalence using a structured diagnostic interview. In comparison many other studies utilise self-report questionnaires. The second reason why prevalence rates may not always be comparable relates to the period of symptom reporting. The 2010 ADF Mental Health Prevalence and Wellbeing Study [25] measured symptoms over the previous 12 months, whereas many studies including the MEAO Prospective Study, only consider symptoms if they occurred in the previous month.

7.5.1 Associations with change between pre- and postdeployment

Changes in PTSD symptoms as measured by the PCL-C between pre- and postdeployment were significantly associated with a number of other factors relating to the most recent deployment. Specifically, increases were significantly associated with the length of the most recent deployment, the role on most recent deployment and the number and type of traumatic deployment experiences on the most recent deployment. There was no association with either time away on or number of prior deployments, or previous combat exposure. The lack of association between changes in PTSD symptoms and prior deployments may reflect the possibility that symptomatic individuals are less likely to re-deploy, indicative of the healthy soldier effect.

7.5.2 Length of most recent deployment

The relationship between the time spent away on the most recent deployment and changes in PTSD symptoms was statistically significant. Respondents who were away on deployment for less than six months had smaller increases in mean PCL-C scores than those who were away for six to seven months and nine to twelve months. In comparison to the results for psychological distress (Chapter 5) and also depression (Chapter 6), respondents who were away on deployment for eight months also had a higher mean increase in PCL-C between pre- and post-deployment than those away for less than six months.

A number of other studies have focused on the prevalence of PTSD in troops deployed to Afghanistan and Iraq. Studies from the U.S. and U.K. have reported post-deployment rates of symptoms consistent with a PTSD diagnosis, ranging from 1.4% [27] up to 13% [28]. Studies have also suggested lengthy deployments may be a risk factor for the development of PTSD post-deployment. A review of records from 678,227 US service personnel, found that compared to shorter deployments, being away for more than 180 days increased the odds of PTSD from 1.11 up to 2.84 times, depending on the service [29].

Nevertheless, the association between length of most recent deployment and changes in PTSD symptoms may not be conclusive. While the association between length of time on most recent deployment and change in mean PCL-C scores was statistically significant, the association with PCL-C change category (Increase, Decrease, No Change) was not. The difference between these outcomes may also reflect the two approaches to analysis. While the mean (continuous) score was averaged across different types of change (i.e. increase or decrease), categorical outcomes were treated as separate groups.

7.5.3 Role on most recent deployment

This study also found that being in a combat role or working outside of the main support base was associated with a larger increase in PCL-C scores between pre-

and post-deployment, in comparison to working in a main support base or working in areas outside of Afghanistan. In addition, the association with PCL-C change category (Increase, Decrease/No Change) was also statistically significant. These findings suggest that combat and combat support roles are associated with increases in PTSD symptoms. Significantly higher incidences of PTSD have also been found in other studies of military populations exposed to combat [30]. One study [27] found that military personnel with combat exposure in Iraq and Afghanistan reported significantly higher rates of PTSD (7.6% to 8.7%) compared to those without combat exposure (1.4% to 2.1%). Similarly, a review of PTSD prevalence across different war eras suggested that higher rates of PTSD reported by Vietnam veterans may reflect increased combat exposure for this theatre relative to other war eras [i.e. Gulf War 1990-91, Iraq war] [31].

7.5.4 Traumatic deployment experiences

Both the number and type of traumatic deployment experiences on the most recent deployment were significantly associated with a change in reported PTSD symptoms between pre- and post-deployment. Respondents who reported a very high number of traumatic deployment experiences (between 36 and 104 exposures) had the largest increase in PCL-C scores. In addition, respondents who reported having experienced at least one trauma within any of the nine deployment experience categories, also had a significantly greater PCL-C increase than those who were not exposed. Associations between trauma number and type and PCL-C change category were also statistically significant. While most of the participants did not change in PCL-C scores between pre- and post-deployment, respondents who had experienced one or more traumas were significantly more likely to increase in PCL-C scores.

The impact of direct combat engagement is again highlighted by Hoge et al. [16] who reported a positive linear relationship between the prevalence of PTSD and the number of fire-fights experienced by military personnel while on deployment. Studies involving soldiers who had deployed to Vietnam[17], Gulf War 1990-91 [18], and Iraq war [19] have all demonstrated that direct combat exposure, and specifically the act of killing, were significantly associated with increased rates of PTSD together with increased anger, violence and antisocial behaviours.

7.6 Summary

Together with psychological distress and depressive symptoms, this study has also shown that operating in a combat role or outside of the main support base was associated with increased PTSD symptoms between pre- and post-deployment. Increases in PTSD symptoms were also found to be associated with the number and type of traumatic deployment exposures. One additional association which was not found for either increases in psychological distress or depressive symptoms, was an association between length of the most recent deployment and increases in PTSD symptoms. However, while these increases were statistically significant, only a small percentage of the total sample (9.6%) had an increase in PTSD symptom severity between pre- and post-deployment; 88.7% of the sample stayed the same and a further 1.7% experienced a decrease in symptom severity. It is also probable that for some respondents there will be delay between an exposure and the onset of symptoms. Further research, therefore, is required to map the different patterns of symptom trajectories overtime. The next chapter focuses on **alcohol misuse** (Chapter Eight). Once again, after providing a short introduction, an explanation of the primary measures is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature. The final chapter in this section, presents and discusses findings relevant to co-morbidity.

Following sections of this report focus on other health outcomes of interest.

- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- Conclusions and Limitations are presented in Chapter Twenty Two

7.7 Other Chapters of Relevance

- Chapter Nine Psychological Co-morbidity
- Chapter Eleven mTBI
- Chapter Seventeen Personal Relationships
- Chapter Eighteen Relationships with Children
- Chapter Twenty One Allostatic Load

7.8 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

- Is there an interaction between the various deployment-related factors, age and prior exposures, on depressive symptoms?
- What factors are associated with different trajectories of depressive symptoms (decreasing, stable and increasing symptoms)?
- What is the impact of the pre-deployment symptom interpretation questionnaire, on the pattern of depression symptom reporting?
- Is there a hierarchy of depressive symptoms that emerges in the postdeployment environment?
- Are there particular exposures, risk factors and deployment histories associated with sub-syndromal and low levels of PTSD symptoms at post-deployment?
- What are the potential reasons for variations in psychological distress between groups with different deployment lengths? In particular, what might set apart those that were deployed for 8 months in comparison to those that were deployed for 6 to 7 months and 9 to 12 months.

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Chapter Eight – Alcohol Misuse

Key Points

- 1. Just over **67% of participants scored below the ADF cut-off** for alcohol at post-deployment, as measured by the AUDIT.
- 2. The overall change in alcohol use between pre- and post-deployment was **not statistically significant.**
- 3. There were, however, significant associations between increased alcohol use and several factors connected to the **most recent deployment**.
- 4. Specifically, these **significant associations** were between increased alcohol use and:
 - a longer deployment period (8 months only),
 - being in a combat role or operating outside of the main support base,
 - reporting any of the traumatic deployment experiences; and
 - reporting a very high number (>35) of deployment exposures.
- 5. No significant associations were found between increases in alcohol use between pre- and post-deployment, and factors associated with prior deployments.

This chapter presents and discusses the findings relating to changes to alcohol misuse between pre- and post-deployment. The chapter begins by briefly discussing current literature pertaining to alcohol misuse. Primary results are then provided, beginning with a comparison of the mean pre-deployment PTSD symptom scores, between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. All subsequent analyses within the result sections include only those participants who have completed both the pre- and post-deployment measures. The chapter concludes by discussing the primary findings pertaining to alcohol misuse. Other chapters which also present findings pertainent to the focus of this chapter include Chapter Nine (Psychological Co-morbidity), Chapter Seventeen (Personal Relationships) and Chapter Eighteen (Relationships with Children).

8.1 Introduction

There is mixed evidence regarding the prevalence of alcohol use *disorders* in military populations. The 2010 ADF Mental Health Prevalence and Wellbeing Study found that rates of any alcohol disorder in the ADF were lower than in the general Australian population (12 month prevalence: males 5.6%, females 2.2% vs males 8.8%, females 5.1%) (1). In contrast, rates in US and UK military populations have been found to be *higher* than in their corresponding general populations (2, 3).

Studies have found that rates of binge drinking in the military increase both prior to (4) and immediately after deployments (5). Other factors associated with misuse of alcohol and long term alcohol disorders in military studies, include greater frequency of deployments, and longer time spent away on deployment (6). Combat exposure has also been found to be associated with both short term misuse of alcohol and longer term alcohol use disorders (AUDs) such as alcohol dependence (7). It is possible, however, that an individual's perceived level of combat stress, rather than the exposure itself, determines this increase.

8.2 Measures

The primary outcome of interest in this chapter is alcohol usage which is measured by the AUDIT (see appendix C) at both pre- and post-deployment within the self report questionnaire. The AUDIT examines both the quantity and frequency of alcohol consumption, possible symptoms of dependence, and the reactions or problems related to alcohol. The first eight questions use a five-item continuous scale (scored 0-4), while the last two questions use a three item scale (scored 0, 2 or 4). A total score is reached by adding together the scores from each of the 10 questions.

In addition to the total AUDIT score, this chapter also uses the AUDIT risk zones which are recommended by the World Health Organisation (8), and also currently used by the ADF (9) to identify defence personnel whose drinking may pose a risk to their health or who are already experiencing alcohol-related problems including dependence.

- **Zone I** (scores of 0 7) represents low risk drinkers who may benefit from alcohol education.
- **Zone II** (scores 8 15) represents those who are likely to require simple advice.
- **Zone III** (scores 16- 19) represents those for whom counselling and continued monitoring is recommended.
- **Zone IV** (scores 20 to 40) requires diagnostic evaluation and treatment.

8.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and changes in AUDIT scores from pre- to post-deployment?
- 2. Is there an association between **roles on most recent deployment** and changes in AUDIT scores from pre- to post-deployment?
- 3. Is there an association between the number and type of **traumatic deployment experiences** while on most recent deployment, and change in AUDIT scores from pre- to post-deployment?
- 4. Is there an association between **total length of time spent on deployment** in the previous three years and a change in AUDIT scores from pre- to post-deployment?
- 5. Is there an association between the **number of previous deployments** and a change in AUDIT scores from pre- to post-deployment?
- 6. Is previous **combat experience** associated with changes in AUDIT scores from pre- to post-deployment?

8.2.2 Sample Sizes

The total sample size used **to identify change between pre- and post-deployment** psychological distress scores was 1,210. Of the 1,324 participants who completed both a pre- and a post-deployment questionnaire, 47 participants did not complete the AUDIT measure at pre-deployment, 60 did not complete it at post-deployment, and seven participants did not complete the measure at either pre- or post-deployment.

The total sample size used **to compare the mean pre-deployment** AUDIT scores for pre-deployment only participants, with pre- and post-deployment participants, was 516. Of the 547 participants who completed a pre-deployment questionnaire only, 31 participants did not complete the AUDIT measure at pre-deployment.

There may also be some variation to the sample sizes used within each of the result sections due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

8.2.3 Data Analysis

Two analysis strategies were used in the following chapter.

First, a mixed model for repeated measures was used to analyse continuous AUDIT score. This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post) and their interaction(s) are included as fixed effects in the model.

Second, scores on the AUDIT were categorised into 4 zones according to WHO guidelines (Zone I, Zone II, Zone III, Zone IV) at pre-deployment and post-deployment. Stepwise change across zones (1 step, 2 step, 3 step) between preand post-deployment was then calculated for each participant. For the purposes of modelling, these changes were then simplified into three change categories ('Increase', 'Decrease' or 'No change'). The change categories were then used as a three level categorical outcome in a multinomial logit model. This approach allowed for the shift in severity of symptoms between the two time points to be examined. In all models the default reference category was 'No change'. Where a different reference category was used, this is stated in the text.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

8.3 Results

A comparison of the mean pre-deployment AUDIT scores for respondents who only completed a pre-deployment survey, and those who completed a pre- and post-deployment survey was undertaken (see Table 8.1, Appendix O). Pre-deployment mean AUDIT scores were significantly higher (p= 0.0006) for respondents who only

completed a pre-deployment survey in comparison to those who completed both a pre- and post-deployment survey.

For respondents who completed AUDIT at both pre- and post-deployment, the mean AUDIT scores were 6.7 and 6.8 respectively (difference = 0.1, 95% CI -0.1, 0.3), and this change (Figure 8.1) was not significant (p=0.26) (see Table 8.2, Appendix O).



Figure 8.1: Distribution of change in mean AUDIT scores between pre- and post-deployment.

The number and percentage of pre- and post-deployment responders in each AUDIT risk category (Zone I scores of 0 to 7, Zone II scores 8 to 15, Zone III scores 16 to 19, Zone IV scores 20 to 40) is presented in Table 8.3.

AUDIT Post						Total	
		Zone I Risk N(%)	Zone II Risk N(%)	Zone III Risk Zone IV Ris N(%) N(%)		N	
Pre	Zone I Risk	694 (57.3%)	121 (10.0%)	6 (0.5%)	7 (0.6%)	828	
	Zone II Risk	123 (10.2%)	178 (14.7%)	21 (1.7%)	15 (1.2%)	337	
	Zone III Risk	1 (0.1%)	18 (1.5%)	8 (0.7%)	5 (0.4%)	32	
	Zone IV Risk	2 (0.2%)	6 (0.5%)	1 (0.1%)	4 (0.3%)	13	
	Total N	820	323	36	31	1210	

Table 8.3:	Change	in AUDIT	categories	at pre-	and	post-der	olovment
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Of these responders, 73.1% did not change AUDIT zones between pre- and postdeployment. However, 14.4% of respondents increased at least one zone, while 12.5% of respondents decreased at least one zone (see Tables 8.4 and 8.5, Appendix O). Table 8.6 presents the change according to the epidemiological cut-offs developed by the 2010 Mental Health and Wellbeing Survey (10). These cut-offs are designed to bring the number of false positives and false negatives closest together and therefore is the closest estimate to the true prevalence of any 30-day ICD-10 alcohol disorder.

	AUDIT		Post	Total N
		Below epi- cut-off	Above epi- cut-off (≥20)	
Pre	Below epi-cutoff	1170 (96.7%)	27 (2.2%)	1197
	Above epi-cutoff (≥20)	9 (0.7%)	4 (0.3%)	13
	Total N	1179	31	1210

Table 8.6: Change in alcohol disorders using epidemiological cut-offs developed by the 2010 MentalHealth and Wellbeing Survey between pre- and post-deployment

Of most interest in this table, is the number of participants who met the epidemiological cut-off at post-deployment (n=31).

8.3.1 Length of Most Recent Deployment

The means for the effect of length of recent deployment on changes to AUDIT scores between pre- and post-deployment is presented in Table 8.7.

Length of most recent deployment (months)	N	Pre-deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% Cl)
≤ 5months	373	5.79	5.32	-0.47
		(2.57, 6.31)	(4.77, 5.86)	(-0.85, -0.10)
6 or 7 months	366	6.24	6.51	0.27
		(5.67, 6.82)	(5.92, 7.11)	(-0.11, 0.65)
8 months	265	5.39	6.01	0.62
		(4.74, 6.05)	(5.33, 6.69)	(0.18, 1.06)
9-12 months	206	5.75	6.04	0.29
		(5.06, 6.45)	(5.32, 6.77)	(-0.21, 0.79)

Table 8.7: Mean (95% CI) AUDIT score for length of most recent deployment.

As can be seen from Table 8.7 the change in AUDIT scores between pre- and postdeployment was significantly different between the four categories of time away on most recent deployment (p=0.001). In particular, mean AUDIT scores, between preand post-deployment, decreased significantly for those who were away on deployment for \leq 5 months (p=0.01), whereas the mean AUDIT scores significantly increased between pre- and post-deployment for those who were away for 8 months (p=0.006) (see Figure 8.2).



Figure 8.2: Mean AUDIT score for length of most recent deployment for pre- and post-deployment

An analysis of the proportion of participants in each AUDIT change category (Increase, Decrease, No change), for the different 'length of most recent deployment' categories, was also undertaken (Table 8.8, Appendix O). Using '<=5 Months' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between the length of most recent deployment and AUDIT change categories.

8.3.2 Role on Most Recent Deployment

The means for the effect of role on changes to AUDIT scores between pre- and postdeployment are presented in Table 8.9.

Role on recent deployment	N	Pre-deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% CI)
Combat Afghan &	624	6.25	6.80	0.55
Outside MSB		(5.56 <i>,</i> 6.95)	(6.10, 7.51)	(0.26, 0.84)
Inside MSB	275	6.12	5.76	-0.36
		(5.45, 6.79)	(5.07, 6.46)	(-0.79, 0.08)
Outside Afghan	310	5.72	5.39	-0.33
		(5.17, 6.27)	(4.82 <i>,</i> 5.97)	(-0.74, 0.08)

 Table 8.9: Mean (95% CI) AUDIT score for length of most recent deployment.

As can be seen in Table 8.9, the change in AUDIT score, between pre- and postdeployment for those whose role was combat or those who worked outside a main support base was significantly greater, on average, than the change in AUDIT scores for those whose role was inside a main support base (p=0.0007) and for those outside of Afghanistan (p=0.0006) (see Figure 8.3).



Figure 8.3: Change in mean AUDIT score between pre- and post-deployment by role categories.

An analysis of the percentage of participants in each AUDIT change category (Increase, Decrease, No change), for the different 'role on most recent deployment' categories, was also undertaken (Table 8.10, Appendix O). Using 'Outside Afghan' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between the role on most recent deployment and AUDIT change categories.

8.3.3 Number of Traumatic Deployment Exposures

The means for the effect of the number of traumatic deployment experiences on changes to AUDIT scores (n = 1180) are presented in Table 8.11.

Deployment exposure (category)	N	Pre- deployment (95% Cl)	Post- deployment (95%Cl)	Change (95% CI)
Low	337	5.67 5.14, 6.19)	5.31 (4.76, 5.86)	-0.36 (-0.75, 0.03)
Medium	259	5.94 (5.29, 6.59)	5.84 (5.16, 6.52)	-0.10 (-0.55, 0.34)
High	290	6.31 (5.68, 7.05)	6.67 (5.91, 7.44)	0.36 (-0.05, 0.79)
Very High	294	7.02 (6.25, 7.79)	7.72 (6.93, 8.51)	0.70 (0.28, 1.12)

Table 8.11:	Mean	(95% CI) Audit score	traumatic de	plovment	exposure
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As can be seen in Table 8.11, the change in AUDIT scores was significantly different between the four categories of deployment exposure (p=0.002). This difference is most likely due to the Very High category which showed the greatest change in mean AUDIT scores between pre- and post-deployment compared to all other categories (see Figure 8.4)



Figure 8.4: Change in mean AUDIT score between pre- and post-deployment by traumatic deployment exposure categories.

The proportion of participants increased, decreased or reported no change for each number of deployment exposure scores are presented in Table 8.12 (Appendix O). Using 'low exposures' as the predictor reference, and 'no change' as the outcome reference, there was no significant associations between the number of deployment exposures and changes to AUDIT scores between pre- and post-deployment.

8.3.4 Traumatic Deployment Experiences

The proportion of respondents who had indicated at least one exposure to each of the nine categories of deployment experience is summarised in Table 8.13, along with the associated change in AUDIT scores between pre- and post-deployment. Note that each respondent could have responded positively to more than one item.

Deployment		Exposed	Unexposed			
Experiences	Number	Change PCL-C	Number	Change PCL-C		
	(%)	Scores (95% CI)	(%)	Scores (95% CI)		
Coming under fire	860	0.29	319	-0.26		
	(72.9%)	(0.04, 0.53)	(27.1%)	(-0.66, 0.14)		
Vulnerable situations or fear of events	826	0.39	354	-0.45		
	(70.0%)	(0.14, 0.64)	(30.0%)	(-0.83, -0.07)		
Casualties among those close to you	715	0.39	459	-0.27		
	(60.9%)	(0.12, 0.66)	(39.1%)	(-0.61 <i>,</i> 0.06)		
Seeing/handling dead bodies	573	0.51	600	-0.23		
	(48.9%)	(0.21, 0.81)	(51.2%)	(-0.52, 0.06)		
In danger of being	571	0.51	604	-0.21		
killed/injured	(48.6%)	(0.21, 0.81)	(51.4%)	(-0.50, 0.08)		
Discharging own	317	0.68	860	-0.06		
weapon	(26.9%)	(0.28, 1.08)	(73.1%)	(-0.31, 0.18)		
Unable to respond to a threatening situation	236	0.50	937	0.04		
	(20.1%)	(0.03, 0.97)	(79.9%)	(-0.19, 0.28)		
Human degradation	159	0.69	1012	0.03		
	(13.6%)	(0.12, 1.25)	(86.4%)	(-0.19, 0.26)		
Actions resulting in	91	0.30	1083	0.12		
injury or death	(7.8%)	(-0.46, 1.05)	(92.3%)	(-0.10, 0.34)		

 Table 8.13: Mean (95% Cl) Audit score traumatic deployment exposure categories.

Coming under fire, exposure to vulnerable situations or fear of events and casualties among those close to you were the most common deployment experiences reported by respondents.

For each traumatic deployment experience, the change in AUDIT scores between pre- and post-deployment was, on average greater for those who were exposed to that experience, compared to those who did not report exposure to that experience. This difference was statistically significant at the 5% level for almost all experiences except 'Being unable to respond to a threatening situation' (p=0.09) and 'Actions resulting in injury or death' (p=0.65).

The proportion of respondents in each AUDIT change category (Increase, Decrease, No change), who had indicated Yes or No to at least one exposure in each of the nine categories of traumatic deployment experiences is summarised in Table 8.14. Note that each respondent could have responded positively to more than one item.

Deployment Experiences			Exposed			Unexposed					
	Yes N	Percentage	AUDIT Increase	AUDIT Decrease	AUDIT No change	No N	Percentage	AUDIT Increase	AUDIT Decrease	AUDIT No change	
Coming under fire	860	72.9%	16.3%	12.4%	71.3%	319	27.1%	8.8%	11.6%	79.6%	
Vulnerable situations or fear of events	826	70.0%	17.8%	12.5%	69.7%	354	30.0%	5.9%	11.6%	82.5%	
Casualties among those close to you	715	60.9%	17.9%	12.0%	70.1%	459	39.1%	8.5%	12.6%	78.9%	
In danger of being killed/injured	571	48.6%	18.0%	12.8%	69.2%	604	51.4%	10.8%	11.7%	77.5%	
Seeing/handling dead bodies	573	48.8%	19.6%	12.9%	67.5%	600	51.2%	9.2%	11.7%	79.1%	
Discharging own weapon	317	26.9%	21.1%	13.6%	65.3%	860	73.1%	11.8%	11.7%	76.5%	
Unable to respond to a threatening situation	236	20.1%	20.3%	16.1%	63.6%	937	79.9%	12.7%	11.3%	76.0%	
Human degradation	159	13.6%	21.4%	14.5%	64.1%	1012	86.4%	12.9%	12.0%	75.1%	
Actions resulting in injury or death	91	7.8%	18.7%	13.2%	68.1%	1083	92.2%	13.8%	12.2%	74.0%	

Table 8.14: Percentage of respondents in each AUDIT change category, for those who answered Yes vs No to at least one exposure for each experience.

Using 'No exposure' as the predictor reference, and 'Decrease' as the outcome reference, while the vast majority of participants did not change in AUDIT scores between pre- and post-deployment, a greater proportion of participants who reported exposure to 'Vulnerable situations or fear of events' increased in AUDIT score compared to those participants who did not report this experience (p=0.02, OR=2.26, 95%CI 1.12, 4.54).

8.3.5 Number of Prior Deployments

The means for the effect of prior deployments on changes to AUDIT score (n = 1098) are presented in Table 8.15 (Appendix O). As can be seen from this table the change in AUDIT score between pre- and post-deployment is not significantly different between the four deployment categories.

An analysis of the percentage of participants in each AUDIT change category (Increase, Decrease, No change) for the different 'number of prior deployment' categories was also undertaken (Table 8.16, Appendix O). Using 'None' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between the number of prior deployments and AUDIT change category.

8.3.6 Total Time on Prior Deployments

The means for the effect of prior deployments on changes to AUDIT scores (n = 896) between pre- and post-deployment is presented in Table 8.17 (Appendix O). As can be seen from this table the change in AUDIT score between pre- and post-deployment is not significantly different between the four prior deployment time categories.

An analysis of the percentage of participants in each AUDIT change category (Increase, Decrease, No change), for the different 'total time on prior deployment' categories was also undertaken (Table 8.18, Appendix O). Using 'None' as the predictor reference, and 'No change' as the outcome reference, there was no significant effect of time spent on deployment over the last three years on AUDIT category change.

8.3.7 Previous Combat Experiences

The means for the effect of previous combat experience on changes to AUDIT scores (n = 1181) are presented in Table 8.19 (Appendix O). While AUDIT scores, on average, decreased between pre- and post-deployment for those who had previously been exposed to combat and increased between pre- and post-deployment for those who previously had not been on a combat role, this difference was not statistically significant.

An analysis of the percentage of participants in each AUDIT change category (Increase, Decrease, No change) for participants who had, and had not reported previous combat exposure, was also conducted (Table 8.20, Appendix O). Using 'Yes' as the predictor reference, and 'no change' as the outcome reference, there was no significant association between previous combat exposure and AUDIT category change.

8.4 Summary of Results

Table 8.21 summarises the key findings presented in this results section in relation to the questions posed in section 8.2.1 of this chapter. A discussion section which

draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Length of most recent deployment	For those participants who were away on deployment for ≤5 months, mean AUDIT scores decreased significantly between pre- and post-deployment. In contrast, mean AUDIT scores significantly increased between pre- and post-deployment for those who were away for 8 months.
Q2. Role on most recent deployment	The increase in mean AUDIT scores between pre- and post- deployment was greater for those in a combat role or who operated outside a main support base, than for those whose role was inside a main support base and those who were Outside Afghan.
Q3a. Number of traumatic deployment exposures	Those participants who had a Very High number of traumatic deployment exposures showed the greatest increase in AUDIT scores between pre- and post-deployment.
Q3b. Traumatic deployment experiences	For all nine deployment experiences, the change in PCL-C score between pre- and post-deployment was significantly greater for those exposed compared to not exposed. For each traumatic deployment experience, except being unable to respond to a threatening situation, and actions resulting in injury or death, the increase in AUDIT scores between pre- and post- deployment was significantly greater for those who were exposed to that experience, compared to those who were not exposed. The proportion of participants whose AUDIT scores increased was greater for those who reported exposure to vulnerable situations or fear of events compared to those participants who were not exposed to this experience.
Q4. Total time on prior deployments	Nil
Q5. Number of prior deployments	Nil
Q6. Previous combat exposure	Nil

Table 8.21: Summary of key findings presented in this chapter

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8.5 Discussion

The overall mean AUDIT score for participants who completed both the pre- and post-deployment AUDIT was 6.7 at pre-deployment and 6.8 at post-deployment and this change was not statistically significant. However, both the pre- and postdeployment mean AUDIT scores were higher than the mean scores (6.0) reported for both deployed and non-deployed ADF personnel in the recently completed 2010 ADF Mental Health Prevalence and Wellbeing Study (10).

A comparison with respondents who completed only the pre-deployment self report questionnaire found that there was a significant difference between these groups in

mean AUDIT score at pre- deployment. On average, those respondents who only completed a self report questionnaire at pre-deployment drank more often (frequency) and/or larger quantities of alcohol (volume) than those who completed both a pre- and post-deployment self report questionnaire.

At pre-deployment, 1.1% of participants who completed both a pre- and postdeployment questionnaire fell within Zone IV which suggests that the individual requires diagnostic evaluation and treatment, while 2.6% of participants reported a score within this high zone at post-deployment. The percentage of respondents reporting high levels of alcohol misuse in this study was similar to other ADF studies. For example, the Mental Health and Wellbeing Study (10) found that 1.4% of regular serving deployed and non-deployed ADF personnel, and the MEAO Census Study (11) found that 1.3% of regular serving personnel who had been to the MEAO fell within Zone IV.

8.5.1 Associations with change between pre- and postdeployment

Associations between a number of factors including length of most recent deployment, role type as well as the number and type of traumatic deployment experiences and changes in alcohol usage as measured by the mean AUDIT scores were found to be statistically significant. While the following discussion focuses on these statistically significant associations it should be noted that the association between AUDIT change category (Increase, Decrease, No Change) was not significant. This difference may reflect the two approaches to analysis. While the mean (continuous) score was averaged across different types of change (i.e. increase or decrease), categorical outcomes were treated as separate groups.

8.5.2 Length of most recent deployment

The association between length of most recent deployment and changes in alcohol usage between pre- and post-deployment was statistically significant. Mean AUDIT scores significantly increased for those who were away for eight months or more, while mean AUDIT scores decreased for those who were away for less than six months. In this study, findings regarding associations between length of most recent deployment and psychological symptoms have also been mixed. In previous chapters, for example, findings have identified no association between length of most recent deployment and depressive symptoms (Chapter Six), while length of deployment was associated with changes in psychological distress (Chapter Five) and PTSD symptoms (Chapter Seven).

Nevertheless, deployment has previously been shown to be associated with heavy episodic alcohol consumption in other military studies (5). Approximately 36% of United States military personnel returning from Afghanistan and Iraq were found to have met the criteria for alcohol misuse (12). Similarly, Calhoun et al (13) found 40% of returning Afghanistan and Iraq military personnel admitted to possibly hazardous alcohol consumption and Seal et al (14) found approximately 10% of Afghanistan and Iraq veterans had received an AUD diagnosis.

The potential association between deployment and increased alcohol consumption is, however, not as clear as the above literature suggests. First, there is no consistency in the rates of alcohol misuse in returned veterans. In a sample of 800 United States Vietnam veterans, 54% reported a lifetime history of alcohol abuse and/or dependence and 17% reported a 12 month history (15). Yet a study (16) involving 12,072 personnel who were no longer in active duty found that while over half of this sample had used alcohol in the preceding month, there was no difference between veterans and non veterans for the prevalence of diagnosed AUD in the

previous 12 months. In addition, while nearly one quarter of the veterans reported binge drinking, this rate was comparable with the general population, and wouldn't necessarily be classified as 'problem dinking'. Second, despite heavy restrictions on consumption of alcohol by military personnel while on deployment, approximately one quarter of troops reported using alcohol when deployed (17). Restriction of alcohol may encourage binge drinking both pre- and post-deployment, as levels of hazardous alcohol use have been found to increase just prior to a new deployment (4).

In the MEAO study, the finding of decreased alcohol consumption for those deployed for less than 6 months probably reflects adherence to alcohol restrictions while on deployment. This, combined with the contrasting finding of an increase in alcohol consumption for those deployed for 8 months (but not those deployed for 6-7 or 9-12 months), suggests that it may not be the length of the deployment that is driving this change.

One study has proposed that the interplays between how recently the deployment occurred, how many total deployments a person had experienced and how long the deployment was for determines the likelihood of alcohol misuse and long term AUD (6). A study of 56,137 active duty US air force personnel, found that the more recent the deployment, the greater the number of deployments, and the overall amount of time spent on deployments predicted higher likelihood of problem drinking. However, while the MEAO Prospective Study found an association between the time spent on the most recent deployment and alcohol misuse, it did not find that there was any association between the number of and/or time spent on prior deployments in the last three years and changes to alcohol consumption. One reason for this may be that personnel who have a psychological disorder such as alcohol misuse may be less likely to deploy (18).

8.5.3 Role on most recent deployment

Being in a combat role or working outside of the main support base was also significantly associated with an increase in alcohol use. Combat stress is a particularly important 'military specific' factor that could encourage the misuse of alcohol (19). Exposure to combat in itself has been shown to be associated with increased alcohol misuse and long term AUD (7, 20, 21). Westermeyer et al. (22) found that in a group of American Indian personnel, those who had experienced direct combat exposure were 36% more likely to be problem drinkers than those who did not. In a study of twins from the Vietnam era (23) higher exposure to combat was associated with an increased prevalence of alcohol dependence. Even after controlling for the effects of PTSD (which is highly prevalent in this population, and itself is directly associated with alcohol dependence), combat exposure was still significantly associated with alcohol dependence. Using data from the US Millennium Cohort Study, Fear et al (24) also found that combat exposure was associated with heavy alcohol consumption among military personnel.

The association between combat and alcohol misuse and AUD may not be as clear as the above studies suggest. While Jacobson et al (25) found an increased risk of new onset alcohol issues following combat exposure for reservists, this was not the case for active duty personnel. The suggestion being that 'preparedness' (possibly higher for active duty personnel, through experience, compared to reservists) may reduce potential negative impacts of combat exposure. A longitudinal study of US military personnel deployed to Iraq also found that while higher levels of drinking were associated with higher pre-deployment stress, there was no relationship between combat exposure and drinking (26).

8.5.4 Traumatic Deployment Experiences

Unlike the MEAO Census Study (11) which found that very few traumatic deployment experiences were associated with alcohol use, the majority of exposure categories in this study were associated with a statistically significant increase in alcohol use between pre- and post-deployment. The only two exceptions to this were being 'unable to respond to a threatening situation' and 'actions resulting in injury or death'. In addition, those who reported between 36 and 104 traumatic deployment exposures on the most recent deployment also had a significantly higher increase in alcohol use between pre- and post-deployment.

One of the signature traumatic deployment exposures in recent years has been the improvised explosive device. Although the mortality rate is low, improvised explosive devises often result in a number of injuries, particularly for individuals in close proximity to the blast. In other cases, soldiers may incur a mTBI without a serious physical injury. Researchers have found a slightly higher proportion of alcohol abuse in veterans with mTBI (27). Bjork and Grant (28) also examined whether mTBI could impact on levels of substance abuse including alcohol. They suggested that TBI interferes with the way the brain processes various neurotransmitters, making it more likely for substance abuse to lead to addiction or dependency. Alternatively, they proposed that TBI may impact on executive function, impairing decision making and impacting on risky alcohol consumption in this way. A more specific discussion as well as analyses of associations between reported mTBI and alcohol abuse will be provided in Chapter Eleven of this report.

8.6 Summary

This study found that a number of factors relating to deployment were associated with changes to alcohol consumption. While the findings were mixed regarding the association between length of deployment and changes to alcohol use, the associations with role on most recent deployment, and number and type of traumatic deployment exposures were less equivocal. Specifically, operating in a combat role or outside of the main support base was associated with increased alcohol use. Likewise, increases in alcohol use were associated with both the number and type of traumatic deployment exposures. However, it is important to note that 67.7% of this sample were considered 'low risk drinkers'. In addition, while 14.4% of respondents reported an increase in their level of drinking from pre- to post-deployment, a further 12.5% reported a decrease in their level of alcohol consumption over the same time period.

The final chapter in this section focuses on **psychological co-morbidity** (Chapter Nine). Once again, after providing a short introduction, the primary results are presented and discussed. Further sections within this report focus on:

Following sections of this report focus on other health outcomes of interest.

- Physical Health Outcomes in Section Three,
- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- **Conclusions and Limitations** are presented in Chapter Twenty Two

8.7 Other Chapters of Relevance

- Chapter Nine Psychological Co-morbidity
- Chapter Seventeen Personal Relationships
- Chapter Eighteen Relationships with Children

8.8 Further Analyses

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

- Is there an interaction between the various deployment-related factors, age and prior exposures, on alcohol usage?
- What factors are associated with different trajectories of alcohol usage (decreasing, stable and increasing symptoms) between pre- and post-deployment?
- What are the potential reasons for variations in alcohol usage between groups with different deployment lengths? In particular, what might set apart those that were deployed for 8 months in comparison to those that were deployed for 6 to 7 months and 9 to 12 months.

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Chapter Nine – Psychological Co-Morbidity at Post-Deployment

Key Points

- 1. While **52% of participants scored below the ADF cut-off for psychological distress, PTSD symptoms and high alcohol usage**, 6% of participants met the criteria for all three psychological conditions, 12% for two and 30% for one of these psychological conditions at post-deployment.
- 2. Co-morbidity was statistically significantly associated with a number of factors related to the **most recent deployment**.
- 3. Specifically, these **significant associations** were between an increase in the number of psychological conditions at post-deployment and:
 - a longer deployment period (6 to 7 months and 9 to 12 months but not 8 months),
 - being in a combat role or operating outside of the main support base,
 - reporting a number of different traumatic deployment experiences,
 - reporting a greater number of traumatic deployment exposures; and
 - smoking behaviour while on deployment.
- 4. A **significant association** was also found between an increase in the number of psychological conditions at post-deployment and the number of prior lifetime traumas reported at pre-deployment.

This final chapter in Section Two focuses on the co-morbidity for the psychological symptoms covered in this section of the report. The chapter begins by briefly discussing current literature pertaining to psychological co-morbidity. Primary results are then provided, beginning with the level of association between the psychological measures used in the MEAO Prospective Study. The chapter then identifies different levels of psychological co-morbidity within the pre- and post-deployment sample. Variables which may be associated with the different levels of co-morbidity are then examined. This chapter concludes by discussing the primary findings pertaining to psychological co-morbidity. Other chapters which also discuss findings pertinent to the focus of this chapter include Chapter Ten (Somatic Symptoms), Chapter Eleven (mTBI), Chapter Twelve (Cardiovascular Health), Chapter Thirteen (Respiratory Health), Chapter Seventeen (Personal Relationships), Chapter Eighteen (Relationships with Children) and Chapter Twenty One (Allostatic Load).

9.1 Introduction

High levels of co-morbid psychological distress, depressive symptoms, PTSD symptoms, and alcohol misuse have been found in general populations(1). Similarly, high rates of co-morbidity have also been found in veteran populations. The 2010
ADF Mental Health Prevalence and Wellbeing Study (2), for example, reported that a quarter of ADF members who met criteria for a mental disorder, had at least one other co-morbid condition. Co-morbid psychological disorders have also been found in US (3), and UK military populations who have deployed to the MEAO (4).

For some conditions, such as depression and PTSD, co-morbidity rates are particularly high, even after removing items that overlap between the disorders (5). A recent study found that 18% of all US military personnel diagnosed with a major depressive disorder met the criteria for PTSD. Black et al (6) also reported higher rates of co-morbid psychological disorders with approximately 80% of US Gulf War veterans with an anxiety disorder, also being diagnosed with depression. However, PTSD has also been found to be associated with a number of other mental health conditions including both general psychological distress and alcohol misuse (4).

In turn, alcohol misuse has also been associated with anxiety as well as mood disorders. Shen et al (7) for example, found that 25% of all US military personnel diagnosed with depression had a co-morbid substance use disorder, although exactly what drug was misused was not identified. A study by Falk et al (8), examined the temporal order of these associations and found that while alcohol use disorder followed the onset of specific and social phobia, alcohol abuse preceded mood and anxiety disorders. Several theories have been posited for this bi-directional association. First, in some cases alcohol may be used to reduce psychological symptoms. Second, the use or misuse of alcohol may exacerbate these symptoms and third, both disorders may be caused be a third factor such as a traumatic exposure (9).

Nevertheless, in some cases reports of co-morbidity may be due to an association between the scales used to measure psychological disorders. For example, Slade et al (10) demonstrated that there is a strong link between K10 scores at the upper end of the range (30+) and the presence of psychopathology. In particular, high K10 scores have been shown to have a strong association with the diagnosis of anxiety and affective disorders using the World Mental Health Composite International Diagnostic Interview (CIDI) (11). The K10 has also been shown to be a successful screening instrument for depression and anxiety more generally (12).

Traumatic exposures including childhood trauma, could also account for the high rates of co-morbidity. For example, deployed personnel reporting four or more childhood traumas, were 4.90 times more likely to be diagnosed with PTSD (95% CI 13.19-7.54), and 5.64 times more likely to be diagnosed with depression (95% CI 3.53-9.03). In addition, two or more childhood traumas significantly predicted posttraumatic stress symptoms, over and above exposure to combat (13).

Smoking has also been found to be significantly associated with a number of mental health conditions. Studies within general populations have found higher rates of cigarette smoking in patients diagnosed with panic disorder (14), the suggestion being that cigarette smoking may play a role in the perceived reduction or control of the negative effects associated with panic disorder (15-17). The uptake of smoking amongst military personnel has also been well documented (18-21). In a recent study of more than 48,000 military personnel, 57% of the cohort started or increased their smoking as a result of deployment. This significant uptake was thought to relate to the stress encountered during deployment (21), suggesting that tobacco was also being used to reduce the symptoms of stress, and this self-medication hypothesis is also likely to apply to other mental disorders (22-24).

Outcomes associated with high levels of co-morbidity can be quite severe. For example, a study involving over 2,616 national guards found that soldiers with PTSD and at least two other psychological disorders were 7.5 times more likely to report suicidal ideation compared to those with only PTSD (3). This finding supports a number of other military studies which have shown that PTSD in combination with other psychological disorders was a risk factor for suicidal ideation (25-27).

9.2 Measures

A detailed description of the outcome measures of primary interest in this chapter may be found in the following sections.

- A description of the **K10** which measures psychological distress can be found in Chapter Five of this report.
- A description of the **PCL-C** which measures PTSD symptoms can be found in Chapter Seven of this report.
- A description of the **AUDIT** which measures alcohol misuse can be found in Chapter Eight of this report.
- A description of the **PHQ-9** which measures depressive symptoms can be found in Chapter Six of this report.

In order to measure co-morbidity in this study, ADF screening criteria (28) were chosen. That is, a respondent was considered to have one or more psychological conditions if they:

- scored equal to or above 15 for the K10,
- scored equal to or above 30 for the PCL-C; and/or
- scored equal to or above 8 for the AUDIT

According to the ADF (28), these are the scores which are likely to identify those military personnel who are at least in a medium risk category and would warrant a further investigation and/or intervention.

For the purposes of this study, co-morbidity groups were categorised as:

- "0" if they did not meet any of the above criteria
- "1" if they met only one of the above criteria
- "2" if they met two of the above three criteria
- "3" if they met all three of the criteria

9.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **the different psychological measures** utilised in this study?
- 2. What are the **different levels** of co-morbidity at post-deployment?
- 3. Is there an association between the different levels of co-morbidity at postdeployment, and **length of most recent deployment**?
- 4. Is **role on most recent deployment** associated with the different levels of comorbidity at post-deployment?
- 5. Is there an association between either the number of type of **traumatic deployment experiences** while on most recent deployment, and the different levels of co-morbidity at post-deployment?
- 6. Is there an association between the **number of prior life traumas**, and the different levels of co-morbidity at post-deployment?

- 7. Is there a relationship between **change in tobacco usage (smoking status and smoking behaviour)** between pre- and post-deployment and the different levels of co-morbidity at post-deployment?
- 8. Is there a relationship between **suicide ideation at pre- and/or postdeployment** and the different levels of co-morbidity at post-deployment?

9.2.2 Data Analysis

First, the associations between K10, PCL-C, AUDIT, and PHQ-9 were examined. However, as the PHQ-9 scores were highly correlated with K10 and PCL-C scores (Table 9.1), and there are no established ADF mental health screening cut-offs for PHQ-9 scores, this measure was not included the calculation of co-morbidity.

Next, in order to define co-morbidity, high scores for K10, PCL-C and AUDIT were examined for those respondents who completed the post-deployment survey. A respondent was considered to be 'at risk' if they scored at least 15 on K10, at least 30 on PCL-C and at least 8 on AUDIT. The number of co-morbidities for each respondent was then calculated by determining the number of scales they were 'at risk' on. The co-morbidity categories were then used as an ordered outcome in a multinomial logit model. This approach allowed for the increasing co-morbidity to be examined.

All models were adjusted for gender (Male, Female), service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks) and age (in years).

9.3 Results

This section begins by looking at the correlations between K10, PCL-C, AUDIT and PHQ-9. The chapter then identifies different levels of psychological co-morbidity within the pre- and post-deployment sample and the variables which may be associated with the different levels of co-morbidity.

9.3.1 Association between different psychological measures

Table 9.1 presents the correlations between K10, PCL-C, AUDIT and PHQ-9.

Correlation	K10 Change	PCL-C Change	AUDIT Change	PHQ-9 Change
	Score	score	score	score
Change K10	1	0.58	0.34	0.67
Score				
Change PCL –C	0.58	1	0.31	0.63
Score				
Change AUDIT	0.34	0.31	1	0.32
Score				
Change PHQ-9	0.67	0.63	0.32	1
Score				

Table 9.1: Correlations between K10, PCL-C, AUDIT and PHQ-9.

As presented in Table 9.1 and Figure 9.1, there is evidence of an association between each of the psychological measures in terms of the change in score between pre- and post-deployment. The strongest positive correlations were between K10 and PHQ-9, and between PCL-C and PHQ-9 change scores.



Figure 9.1: Associations between PHQ-9, AUDIT, PCL-C and K10 change scores

9.3.2 Co-morbidity at Post-Deployment

Of the 1208 respondents who answered the K10, PCL-C and AUDIT items of the post-deployment questionnaire, 627 had no co-morbidities, 357 had only one co-morbidity, 151 had two co-morbidities and 73 people had three co-morbidities (figure 9.2).



Figure 9.2: Co-morbidity between K10, PCL-C and AUDIT at post-deployment for pre- and post-deployment responders

9.3.3 Associations with Psychological Disorders at Pre-Deployment

Of those respondents who had three co-morbid psychological conditions at postdeployment (n = 69), 21.7% (15) had the same three co-morbid psychological conditions at pre-deployment, 24.6% (17) had two, 37.7% (26) had one and 16% (11) had no psychological disorder at pre-deployment and this difference was statistically significant (p<0.0001) (Figure 9.3).



Figure 9.3: Association between number of co-morbidities at pre- and post-deployment.

9.3.4 Length of Most Recent Deployment

Table 9.2 presents the percentage of participants in each co-morbidity category at post-deployment, for the different 'Length of recent deployment' categories.

Length of	N	No	One	Two	Three
Recent		Psychological	Psychological	Psychological	Psychological
Deployment		Conditions	Condition	Conditions	Conditions
<= 5 Months	370	63.5%	24.9%	8.4%	3.2%
6-7 Months	362	45.6%	32.3%	14.6%	7.5%
8 Months	267	49.4%	31.5%	13.9%	5.2%
9-12 Months	209	45.5%	30.6%	14.4%	9.6%

Table 9.2: Association between co-morbidity and length of most recent deployment

As can be seen in Table 9.2, using '<= 5months' as the predictor reference and modelling the probability of a increasing co-morbidity at post-deployment, there was a significant effect for length of most recent deployment on co-morbidity (p=0.008). For those who were away for 6 or 7 months, a greater proportion had more co-morbidities at post-deployment, compared to those who were away for <= 5 months (OR=1.80 95% CI 1.33, 2.43). Similarly, those who were away for 9-12 months had more co-morbidities than those who were away for <= 5 months (OR= 1.60 95% CI 1.12, 2.28). Those who were away for 8 months also had more co-morbidities compared to those who were away for <= 5 months, but this difference was not statistically significant. (OR=1.26 95% CI 0.90, 1.77).

The significant effect of most recent deployment length is illustrated in Figure 9.4, which shows the probability of increasing co-morbidities at post-deployment for each length of recent deployment category. A larger proportion of people with at least one co-morbidity were on deployment for 6-7 months or 9-12 months.



Figure 9.4: Predicted proportion of participants in each category of length of most recent deployment for co-morbidity category. * Note this plot is computed at the average level for age (30.92) and the reference level for gender (Male), service (Army) and rank (Other ranks).

9.3.5 Role on most recent deployment

Table 9.3 shows the percentage of participants in each co-morbidity category at postdeployment for the different 'Role on most recent deployment' categories.

Role on recent deployment	N	No Psychological Conditions	One Psychological Condition	Two Psychological Conditions	Three Psychological Conditions
Combat Afghan & Outside MSB	625	44.0%	31.8%	16.0%	8.2%
Inside MSB	279	54.8%	30.1%	10.0%	5.0%
Outside Afghan	304	65.5%	24.3%	7.6%	2.6%

Table 9.3: Association between co-morbidity and length of most recent deployment

As can be seen in Table 9.3, Using 'Outside Afghan' as the predictor reference and modelling the probability of increasing co-morbidity at post-deployment, there was a significant effect of role on most recent deployment, on co-morbidity (p=0.01). For those who were on a combat role in Afghanistan and outside the main support base, a greater proportion had more co-morbidities compared to those who were in non-combat roles outside Afghanistan (OR 1.79, 95% CI 1.15, 2.78).

The significant effect of role on recent deployment is illustrated in Figure 9.5, which shows the probability of each level of co-morbidity at post-deployment, for each role group. It can be seen that a larger proportion of people in combat roles had more co-morbidities .



Figure 9.5: Predicted proportion of participants in each category of role on most recent deployment for co-morbidity category. * * Note this plot is computed at the average level for age (30.92) and the reference level for gender (Male), service (Army) and rank (Other ranks).

9.3.6 Number of Traumatic Deployment Exposures

Table 9.4 shows the percentage of participants in each co-morbidity category at postdeployment for the different 'number of 'traumatic deployment exposure' categories.

Deployment	Ν	No	One	Two	Three
Exposure		Psychological	Psychological	Psychological	Psychological
(category)		Conditions	Condition	Conditions	Conditions
Low	331	66.8%	23.9%	7.0%	2.4%
Medium	260	53.5%	30.0%	11.5%	5.0%
High	295	46.8%	34.6%	13.6%	5.1%
Very High	295	41.0%	29.5%	18.3%	11.2%

Table 9.4: Association between co-morbidit	v and number of traumati	c deployme	ent experiences
Table 3.4. Association between comorbiant	y and mannoci or craamaci	c acpioyinc	int experiences

As can be seen using 'Low' as the predictor reference and modelling the probability of increasing co-morbidity at post-deployment, there was a significant effect of number of deployment exposures on co-morbidity (p=0.0004). Those who had a very high number of exposures were likely to have more co-morbidities compared to those who had the lowest number of deployment exposures (OR=2.59 95% CI 1.66, 4.03). Similarly those who were categorised as having a high number of exposures (OR=1.84, 95% CI 1.19, 2.85), and those who had a medium number of exposures (OR=1.59, 95% CI 1.07, 2.36) were likely to have more co-morbidities compared to those who had the lowest number of deployment exposures.

The significant effect of number of deployment exposures is illustrated in Figure 9.6, which shows the probabilities of co-morbidities at post-deployment for increasing number of exposures. It can be seen that a larger proportion of the people with a very high number of deployment exposures had three co-morbidities.



Figure 9.6: Predicted proportion of participants in each category of number of deployment exposures for co-morbidity category. * * Note this plot is computed at the average level for age (30.92) and the reference level for gender (Male), service (Army) and rank (Other ranks).

9.3.7 Traumatic Deployment Experiences

The proportion of respondents in each co-morbidity category who had indicated Yes or No to at least one exposure to each of the nine categories of deployment experiences is summarised in Table 9.5 (Appendix P). Note that each respondent could have responded positively to more than one item.

As can be seen in Table 9.5, coming under fire, exposure to vulnerable situations or fear of events and casualties among those close to you were the most common deployment experiences reported by respondents.

Using 'No Exposure' as the predictor reference, all exposures apart from coming under fire, were associated with more co-morbidities at post-deployment compared to those participants who did not report these exposures (see Table 9.6).

Traumatic Deployment Categories	Yes N	OR (95 % CI)	р
Coming under fire	867	1.37 (0.96, 1.96)	0.09
Vulnerable situations or fear of events	831	1.95 (1.39, 2.75)	<0.0001
Casualties among those close to you	719	1.82 (1.36, 2.43)	<0.0001
In danger of being killed/injured	573	1.48 (1.14, 1.93)	0.003
Seeing/handling dead bodies	578	1.50 (1.17, 1.94)	0.002
Discharging own weapon	321	1.38 (1.06, 1.82)	0.02

Table 9.6: Odds ratios (95% CI) for co-morbidity categories, for those respondents who reported Yes vs No to at least one exposure for each experience.

Unable to respond to a threatening situation	237	1.92 (1.45, 2.54)	<0.0001
Human degradation	156	2.42 (1.76, 3.33)	<0.0001
Actions resulting in injury or death	90	1.84 (1.23, 2.75)	0.003

9.3.8 Number of prior life traumas

Table 9.7 shows the percentage of participants in each co-morbidity category at postdeployment for the different 'Prior life trauma' categories.

Prior trauma (category)	N	No Psychological Conditions	One Psychological Condition	Two Psychological Conditions	Three Psychological Conditions
No prior traumas	324	58.0%	29.0%	9.9%	3.1%
1-2 prior traumas	383	58.8%	27.7%	9.9%	3.7%
3-4 prior traumas	239	46.0%	30.1%	17.6%	6.3%
5+ prior traumas	216	38.0%	33.8%	15.7%	12.5%

 Table 9.7: Association between co-morbidity and number of prior life traumas

Using 'No prior traumas' as the predictor reference and modelling the probability of increasing co-morbidity at post-deployment, there was a significant effect of prior life traumas on co-morbidity (p<0.0001). Those who had 5 or more prior traumas were likely to have more co-morbidities compared to those who had no prior traumas (OR=2.28 95% CI 1.63, 3.19). Similarly those who reported 3-4 prior traumas (OR=1.75, 95% CI 1.26, 2.42) were likely to have more co-morbidities compared to those who had no prior traumas

The significant effect of number of prior traumas is illustrated in Figure 9.7, which shows the probabilities of co-morbidities at post-deployment for increasing number of prior traumas. It can be seen that a larger proportion of the people with higher numbers of prior traumas (3-4, 5+) had more co-morbidities.



Figure 9.7: Predicted proportion of participants in each category of number of prior traumas for comorbidity category. * * Note this plot is computed at the average level for age (30.92) and the reference level for gender (Male), service (Army) and rank (Other ranks).

9.3.9 Smoking Status

Table 9.8 shows the percentage of participants in each co-morbidity category at postdeployment for the different 'Smoking status categories.

Smoking Status	N	No Psychological Conditions	One Psychological Condition	Two Psychological Conditions	Three Psychological Conditions
Smoking at Pre	96	51.0%	32.3%	12.5%	4.2%
Smoking at Post	160	41.3%	31.3%	18.1%	9.4%
Smoking at both pre- and post	416	38.9%	37.7%	13.9%	9.4%

Using 'Smoking at pre- only' as the predictor reference, and modelling the probability of increasing co-morbidity at post-deployment, there was no significant effect of smoking status on co-morbidity (p=0.23).

9.3.10 Smoking behaviour

Table 9.9 shows the percentage of participants in each co-morbidity category at postdeployment for the different 'Smoking Behaviour' categories.

Smoking Behaviour	N	No Psychological Conditions	One Psychological Condition	Two Psychological Conditions	Three Psychological Conditions
Did not smoke	161	53.4%	31.1%	9.3%	6.2%
Less than usual	22	63.6%	27.3%	4.6%	4.6%
Same amount	63	61.9%	25.4%	7.9%	4.8%
More than usual	183	32.2%	37.2%	19.1%	11.5%
Began/restart ed smoking	103	30.1%	37.9%	17.5%	14.6%

Table 9.9: Association between co-morbidity and smoking behaviour

Using 'Did not smoke' as the predictor reference and modelling the probability of increasing co-morbidity, there was a significant effect of smoking behaviour on co-morbidity (p<0.0001). Those respondents who began or restarted smoking while on deployment were likely to have more co-morbidities compared to those who did not smoke on deployment (OR=2.22 95% CI 1.36, 3.60). Similarly those who smoked more than usual (OR=2.03, 95% CI 1.33, 3.10) were likely to have more co-morbidities compared to those who did not smoke.

The significant effect of smoking behaviour is illustrated in Figure 9.8, which shows the probabilities of co-morbidities at post-deployment for the different smoking behaviour categories. It can be seen that a larger proportion of people who began or restarted smoking on deployment, or smoked more than usual while on deployment, were likely to have more co-morbidities.



Figure 9.8: Predicted proportion of participants in each category of smoking behaviour for comorbidity category. ** Note this plot is computed at the average level for age (30.92) and the reference level for gender (Male), service (Army) and rank (Other ranks).

9.3.11 Suicide Ideation

Table 9.10 shows the percentage of participants in each co-morbidity category at post-deployment for the different 'Suicide Ideation' Category.

Table 3.10. Fercentage of participants in each co-morbidity category with suicide ideation
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Suicide Ideation	N	No Psychological Conditions	One Psychological Condition	Two Psychological Conditions	Three Psychological Conditions
At post-	19	10.5%	26.3%	31.6%	31.6%
Not at post	1163	52.7%	29.5%	12.2%	5.6%

The number of respondents who reported any suicidal ideation at post-deployment was extremely small (n=19). Of these people, 89.5% had one or more co-morbidities at post-deployment.

9.4 Summary of Results

Table 9.11 summarises the key findings presented in this results section in relation to the questions posed in section 9.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Table 9.11: Summary of key findings	presented in this chapter
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Question	Significant Associations
Q1. Associations between different psychological measures	There was evidence of an association between each of the psychological measures. The strongest positive correlations were between K10 and PHQ-9, and between PCL-C and PHQ-9 change scores.
Q2. Co-morbidity at post-deployment	Of the 1208 respondents who answered the K10, PCL-C and AUDIT items of the post-deployment questionnaire, 627 had no psychological disorders, 357 had only one psychological condition, 151 had two psychological conditions and 73 people had three psychological conditions.
Q3. Length of most recent deployment	Compared to participants who were away for <= 5months, a greater proportion of those who were away for 6 or 7 months or 9-12 months had more co-morbidity at post-deployment.
Q4. Role on most recent deployment	A greater proportion of participants who were on a combat role in Afghanistan and outside the main support base had increased co- morbidity, compared to those who were in non-combat roles outside Afghanistan.
Q5a. Number of traumatic deployment exposures	Those participants who had medium, high and very high numbers of traumatic deployment exposures were likely to have more co- morbidity compared to those who had the lowest number of deployment exposures.
Q5b. Traumatic deployment experiences	All exposures, apart from coming under fire, were associated with more co-morbidity at post-deployment, compared to those participants who did not report these exposures

Q6. Number of prior life traumas	Those participants who had more than 3 prior traumas were likely to have increased co-morbidity compared to those who had no prior traumas.
Q7a. Changes in smoking status	Nil
Q7b. Changes in smoking behaviour	Those participants who began or restarted smoking, and those who smoked more than usual while on deployment, were likely to have more co-morbidity compared to those who did not smoke on deployment.
Q8. Suicidal ideation	Of the 19 participants who reported any suicidal ideation at post- deployment, 89.5% had one or more psychological conditions at post-deployment.

9.5 Discussion

This chapter began by presenting results which suggest that there is a particularly strong correlation between the K10 and PHQ-9 change scores, and between the PCL-C and PHQ-9 change scores between pre- and post-deployment. Other studies have found similar results. For example, Slade et al (10) demonstrated that there is a strong link between K10 scores at the upper end of the range (30+) and the presence psychopathology. High K10 scores have also been shown to have a strong association with the diagnosis of anxiety and affective disorders using the World Mental Health Composite International Diagnostic Interview (CIDI) (11). Given this close association between high K10 scores and PHQ-9 (12) and as the PHQ-9 is not currently used as a post-deployment screening measure by the ADF, the PHQ-9 was not considered in any of the analyses pertaining to co-morbidity, which was the primary purposes of this chapter.

An analysis of co-morbidity found that, of the 1,208 who responded to the K10, PCL-C and AUDIT measures at post-deployment, 73 participants (6.0%) met the criteria for all three co-morbid conditions at post-deployment (K $10 \ge 15$, PCL-C ≥ 30 , AUDIT ≥ 8). A further 151 participants (12.5%) had at least two co-morbid conditions, and 357 (29.6%) reported criteria consistent with a level considered to be 'at risk' for one of these psychological measures. In interpreting the findings in this chapter it is important to emphasise that a cut off of 8 on the AUDIT has very low positive predictive value for detecting alcohol abuse and dependence. There are many individuals scoring over this band who are not drinking in a manner that conveys significant risk. Hence the use of this cut off in relationship to alcohol usage should not be interpreted as abuse but rather a likely indicator of alcohol usage related to psychological distress with the attendant risks of self-medication.

The 2010 ADF Mental Health Prevalence and Wellbeing Study (2) also considered psychological co-morbidity within the ADF. Looking at the prevalence of 12 month ICD-10 disorders, the study found that 0.7% of the ADF population (deployed and non-deployed) met the criteria for three co-morbid disorders (alcohol disorder, anxiety disorder and affective disorder), while 6.2% of the population met the criteria for two and 15.2% met the criteria for one of these disorders. It should be noted that while the rates of co-morbidity reported by the 2010 ADF Mental Health Prevalence Study are already lower than those found at post-deployment in the MEAO Prospective Study, it is possible that there would be a further increase, if the MEAO Prospective Study had also measured a 12 months rather than a 30 day prevalence rate.

A number of other studies have also found significant rates of psychological comorbidity in military populations. For example, Thomas et al (29) examined 13,226 National Guard soldiers who were veterans of Operation Iraqi Freedom. Personnel were tested three months post-deployment and then again at 12 months postdeployment. The study found that the prevalence of high alcohol use, PTSD and depression was greater at 12 months compared to three month interval. The authors suggested that in line with a self-medication hypothesis, alcohol use increased in line with the increase in PTSD and depression symptoms over-time.

Of particular interest in this study is that 58 responders, who met the criteria for a high risk of all three co-morbid psychological disorders at post-deployment, also reported high levels of psychological distress, PTSD symptoms and/or high alcohol use at pre-deployment. In addition, a smaller proportion of responders in each of the other co-morbid groups (none, one or two psychological disorders at post-deployment) also met the criteria for each of the disorders at pre-deployment.

This finding is particularly important because the relationship between pre- and postdeployment psychological health is not clearly understood, primarily because many of the studies which investigate risk factors for post-deployment mental health disorders have employed retrospective methods, making it extremely difficult to accurately ascertain the mental health of personnel before they deploy. One exception, the Millennium Cohort Study, has, however, also found that baseline psychiatric status was significantly associated with mental health at follow-up. Specifically for personnel who had deployed to either Afghanistan or Iraq between completing a baseline and follow-up survey (30). However, it should be noted that there was a significant time lag between baseline and deployment, and again between deployment and completion of the follow-up survey for many of the Millennium Cohort Study participants, which can introduce recall bias.

In comparison, the Kings Centre for Military Health Research longitudinal study found that PCL scores at baseline tended to decrease between baseline and follow-up for those with scores of 30 or more (31). However, this study included both deployed and non-deployed personnel and similar to the Millennium Cohort Study participants there was a significant time lag between baseline data and deployment, and again between deployment and completion of the follow-up questionnaire.

The finding that a number of responders in this study met the ADF screening criteria for at least one high risk psychological condition prior to deploying to the MEAO is also of some concern. Implementing the optimal cut-offs developed by the 2010 ADF Mental Health Prevalence and Wellbeing Study (2) may assist in identifying a greater number of ADF personnel at potential risk of a psychological disorder. These optimal screening cut-offs were designed to identify individuals who might require care and suggests a K10 cut-off of 17 to capture those at risk of an affective and/or anxiety disorder. Similarly, the optimal cut-off of 29 was recommended for the PCL-C and the cut-off of 8 for the AUDIT which is currently used by the ADF should remain.

9.5.1 Associations with Psychological Co-Morbidity at Post-Deployment

Associations between a number of factors and the presence of at least two co-morbid conditions at post-deployment were also considered. Many of the statistically significant associations such as length of most recent deployment, role on most recent deployment and the number and category of traumatic deployment exposures have been reported and discussed in previous psychological health chapters. However, two additional associations, the number of prior life traumas and smoking behaviour, were also found to be statistically significant. Furthermore, while there

were only a small number of participants who reported suicide ideation at postdeployment, there was a trend which suggested that a larger percentage of participants with co-morbidity were reporting suicide ideation. These individuals are of particular concern and highlight the importance of detecting and treating psychological distress in the post-deployment period to minimise the risk of suicide. These additional findings will now be discussed in more detail.

9.5.2 Prior Life Traumas

The number of life traumas experienced by responders prior to deploying was found to be significantly associated with meeting the criteria for all three psychological conditions at post-deployment. Those respondents who had five or more prior life traumas were more than twice as likely to meet the criteria for at least two co-morbid psychological conditions, in comparison to those with no psychological conditions at post-deployment.

This finding demonstrates that events not necessarily related to the respondent's military career may contribute to psychological illness after deployment. This has also been found in a number of other military studies. For example, navy recruits who had experienced childhood victimisation were more likely to use alcohol, in comparison to those without these prior life traumas (32). Seifert et al (33) also examined the possible long term consequences of childhood physical and sexual abuse in a sample of 108 male and 96 female US Army soldiers. They found that problem drinking was higher for personnel who had experienced any type of childhood abuse.

Childhood trauma has also been linked to depression within military populations. In a study comparing US male soldiers who had deployed to Iraq (N = 2392) with those who had not (N = 4529), Cabrera et al (13) found that having two or more adverse childhood experiences was the main predictor of depression rates and severity for both groups. In those deployed to Iraq, adverse childhood events and combat exposure were significant predictors of depression beyond the expected contribution of combat stress.

As well as childhood trauma specifically, previous violent experiences more generally have been found to be associated with an increased risk of PTSD in deployed troops. A study of 11,640 military personnel who completed a survey as recruits and then also completed a follow up survey between three and five years later, found that individuals who had experienced one prior violent exposure were 1.88 times more likely (95% CI: 1.07-3.30) to be diagnosed with PTSD, while those that experienced two or more violent episodes were 2.57 times more likely (95% CI: 1.42-4.67) (34).

These studies lend support to the theory of sensitisation and kindling. There is now a substantial body of research demonstrating how repeated exposures to trauma over a prolonged period increase the risk of morbidity and even mortality (35). Overall, it appears that prior trauma exposure has a cumulative effect on PTSD risk. A Canadian study involving 5,849 male and 2,592 female regular and reserve troops (36) also found that a higher number of lifetime traumatic events predicted experiencing depression in the past year. Similarly, a study of 250 navy health care providers deployed to the Persian Gulf found that negative life events was significantly correlated with depression and/or anxiety and PTSD during deployment (37). This is particularly relevant to military personnel who in addition to being at risk of civilian traumas, often also experience multiple trauma exposures through combat. For example, a study of 8,391 male marines who deployed to Iraq or Afghanistan between 2001 and 2004, for example, found that those who reported multiple adverse childhood experiences at recruitment were significantly more likely to be diagnosed with PTSD at post-deployment. In particular, those that reported physical

neglect as a child were 1.74 times more likely to report PTSD (95% CI = 1.17, 2.59) even after adjusting for other confounds (38).

9.5.3 Smoking Behaviour

This study has also found a statistically significant association between changes in smoking behaviour (indicative of increased smoking) between pre- and post-deployment, and an increased number of co-morbid psychological conditions at post-deployment. Interestingly this association was not significant for smoking status. One possible reason for this inconsistency is that the smoking behaviour questions ask about the change in smoking behaviour while on deployment, while the smoking status question asks for the smoking behaviour prior to and then again at the time of completing the post-deployment questionnaire. It is therefore possible that in some cases, responders did increase or start smoking while on deployment but that pre-deployment smoking behaviour had resumed by the time that the post-deployment questionnaire was completed.

Nevertheless, other military studies have found an association between psychological health and smoking behaviour. For example, Angst and Clayton (39) examined the military conscription records of all men born in Zurich in 1952. They found a relationship between cigarette smoking and depression. They also found that 82% of military conscripts who died by suicide were smoking more than six cigarettes per day.

The Millennium Cohort Study also found an association between smoking and deployment. While 2.3% of deployed personnel started smoking between baseline and the follow-up questionnaire, those in a combat role were 1.6 times more likely to have started smoking, in comparison to those who deployed in a non-combat position (40). This is in line with research in the general population confirming smokers have an increased risk of developing depression during their lifetime (41). Those with depression also find it harder to quit smoking (42).

9.5.4 Suicidal Ideation

Military specific factors such as deployment and combat exposure, and other factors including existing psychiatric conditions (43), a history of adverse events in childhood (43-46), and lifetime trauma exposure (36) have all been shown to be associated with increased suicidality. Likewise, a descriptive analysis of the data in this study also suggests that the majority of responders reporting suicide ideation also met criteria for three co-morbid psychological conditions at post-deployment. However, due to the small number of responders reporting suicide ideation, this finding should be treated with caution.

Nevertheless, both general and military populations have reported a strong association between mental health conditions and suicidality (47). Literature suggests that any mental health diagnosis is a risk factor for suicide (48). For example, a retrospective study of 2,616 national guards found that those respondents with at least two co-morbid psychological disorders (PTSD plus one other disorder) were 5.4 times more likely and those with PTSD and two other psychological disorders were 7.5 times more likely to report suicidality than those without PTSD (3). The 2010 ADF Mental Health Prevalence and Wellbeing Study (2) also found a strong association between various psychiatric disorders and suicidality.

It also appears that the association between different mental health conditions and suicidality is not straightforward, as there is evidence that trajectories vary according to psychological condition. For example, in a longitudinal study of adolescent males Lundin et al. (49) found that any psychiatric diagnosis at baseline predicted an

increased risk of suicide persisting up to 30 years later. The association between depression and suicide, and alcohol and substance abuse and suicide, reduced over time, while the relationship between anxiety and suicide emerged later (18 to 36 year follow-up). The relationship with neurosis and personality disorder persisted, with increased suicide risk still apparent at more than 24 years follow-up.

9.6 Summary

This concluding chapter in the psychological health section demonstrates that the vast majority of participants (52%) scored below the accepted ADF cut-offs for psychological distress measured by the K10, PTSD symptoms measured by the PCL-C and alcohol usage measured by the AUDIT. Nevertheless, approximately 6% of participants scored above the ADF cut-offs for all three measures, 12% for two and 30% for one of these measures. In addition, findings from this chapter show that similar to the previous chapters in this section, co-morbidity is significantly associated with length of most recent deployment (six to seven months or nine to twelve months), reporting exposures in any of the traumatic deployment exposures associated with the most recent deployment. The findings presented in this chapter also show that the number of traumas reported prior to the most recent deployment, smoking behaviour on most recent deployment is also associated with co-morbidity.

This was the final chapter in the section relating to Psychological Health. Section Three which focuses on physical health outcomes begins by introducing the primary theoretical underpinnings which informed the analyses. Also included within Section Three are:

- Somatic Symptoms in Chapter Ten
- **mTBI** in Chapter Eleven
- Cardiovascular Health in Chapter Twelve
- **Respiratory Health** in Chapter Thirteen
- Skin Conditions in Chapter Fourteen
- Infectious Diseases in Chapter Fifteen
- Biochemistry in Chapter Sixteen

Further sections within this report focus on:

- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- **Conclusions and Limitations** are presented in Chapter Twenty Two

9.7 Other Chapters of Relevance

- Chapter Ten Somatic Symptoms
- Chapter Eleven mTBI
- Chapter Twelve Cardiovascular Health
- Chapter Thirteen Respiratory Health
- Chapter Seventeen Personal Relationships
- Chapter Eighteen Relationships with Children
- Chapter Twenty One Allostatic Load

9.8 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

- What factors are associated with different psychological co-morbid categories (none, one, two and three psychological conditions) at post-deployment?
- What is the impact of the pre-deployment symptom interpretation questionnaire, on psychological co-morbidity?
- Are there particular exposures, risk factors and deployment histories associated with psychological co-morbidity at post-deployment?

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Section Three - Introduction to Physical Health

This section focuses on changes to both objectively measured and self reported health outcomes between pre- and post-deployment, with each of the chapters considering a specific physical health outcome. The chapters begin by presenting changes in the prevalence of physical health outcomes within the deploying population according to demographic factors such as age, rank, service, role and deployment location. Each chapter then goes on to present significant findings from the analyses, which were based on a number of theoretical underpinnings.

First, a number of studies have found high levels of co-morbid physical and psychological disorders in deployed military populations. In particular, recent literature has focused on the association between mTBIs and PTSD (1). However, other associations such as mTBI and alcohol misuse (2), as well as pain and psychological disorders (3), are also of interest. Therefore, where appropriate, associations between changes to co-morbid disorders were considered within the analyses, and if significant, presented and discussed.

Second, a number of studies have demonstrated that the number and severity of self-reported physical symptoms is often significantly elevated when there is an opportunity to compare it with objectively measured data (4). Studies have shown that individuals with PTSD and other psychological disorders are, for example, more likely to report elevated somatic symptoms. Rather than relying solely on subjective assessments, the MEAO Prospective Study collected objective health measures prior to and again after deployment in order to identify the physical impacts of combat stress and the other exposures of interest. These measures were able to tap into dimensions of physiological and biological systems known to be dysregulated in illness and disease.

In addition to the benefits of an objective dataset, the longitudinal methodology used in the MEAO Prospective Study also overcomes many of the issues associated with cross-sectional studies, including poor response rates and biases introduced by the lag time between deployment exposures and measurement. In addition, the longitudinal nature employed by this study is designed to capture the trajectories of symptoms (5) necessary for longitudinal surveillance.

The following chapters in this section focus on the physical health outcomes of interest.

- Chapter Ten **Somatic Symptoms**
- Chapter Eleven **mTBI**
- Chapter Twelve Cardiovascular Health
- Chapter Thirteen **Respiratory Health**
- Chapter Fourteen Skin Conditions
- Chapter Fifteen Infectious Diseases
- Chapter Sixteen **Biochemistry**

After providing a short introduction, each chapter describes the measure/s used to identify change, before presenting the primary results. Each chapter concludes with a discussion of these results in relation to the current literature.

Further sections of this report focus on other health outcomes of interest.

- Biomedical Markers in Section Four,
- Social Health in Section Five
- Identifying Possible Risk Markers in Section Six
- Conclusions and Limitations are presented in Chapter Twenty Two

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Chapter Ten – Somatic Symptoms

Key Points

- 1. There was a **statistically significant increase** in the number of somatic symptoms reported between pre- and post-deployment.
- 2. This increase was significantly associated with several factors connected to the **most recent deployment**.
- 3. Specifically, these **significant associations** were between increased number of somatic symptoms and:
 - a longer deployment period (6 to 7 months and 9 to 12 months but not 8 months),
 - being in a combat role or operating outside of the main support base,
 - reporting a number of different traumatic deployment exposures; and
 - reporting a greater number of traumatic deployment exposures.
- 4. Meeting the criteria for three **co-morbid psychological conditions** at postdeployment was associated with:
 - reporting each of the top 15 somatic symptoms at post-deployment; and
 - reporting the greatest number of somatic symptoms at postdeployment.
- 5. No significant associations were found between increases in psychological distress from pre- to post-deployment, and factors associated with prior deployments.

This chapter is the first of the physical health chapters (Section Three) and it presents and discusses the findings pertaining to somatic symptoms. The chapter begins by briefly discussing current literature regarding somatic symptoms and the related literature on multi-symptom illness. Primary results are then provided, beginning with a comparison of the top 15 somatic symptoms at pre- and post-deployment for those participants who responded at both time points. In addition to modelling the association between somatic symptoms and deployment related factors, the chapter also considers the differences between the four co-morbidity groups identified in Chapter Nine (Section Two). The somatic symptoms chapter concludes by discussing the primary findings from the analyses. Findings pertinent to the focus of this chapter are also presented in Chapter Twenty One (Allostatic Load).

10.1 Introduction

Every major conflict of the last 150 years has brought concern about the health of returning veterans (1). Invariably there is a tension between psychosomatic and physical explanations for post-deployment somatic symptoms that are of uncertain causation (2-4). These problems of definition are exemplified in post-deployment

syndromes, where battlefield hazards leave veterans concerned about a range of potential toxic exposures and the effects that they may have on long-term health. Concerns are often then further fanned by confusing scientific disagreements, sensational news media coverage, and rancorous political debate.

The importance of examining these health concerns is highlighted by the fact that two of the most consistent findings from post-deployment studies of Gulf War 1990-91 were the increased reporting of all somatic symptoms, and greater symptom severity by Gulf War veterans compared with non Gulf War comparison groups (5). This finding has been consistently reported in a number of follow-up studies conducted many years after the end of the Gulf War 1990-91 (6). Defence personnel returning from deployments in Iraq have also reported a small increase in the number and severity of symptoms compared to colleagues who did not deploy (7).

Despite the use of sophisticated statistical analytical approaches, studies have not found a consistent cluster or pattern of symptoms that are unique to either of these deployed groups of veterans (8). Likewise, while many exposures have been examined, none have been found to be reliably associated with any symptom cluster (5). More recently researchers have suggested that a range of physical, psychological as well as social, cultural and neurobiological factors are involved in the development of a multi-symptom illness (9, 10).

A number of risk factors for increased symptom reporting post-deployment have been suggested, including sex, age, rank and service, although these are also general risk factors for psychiatric illness in the military (11). In addition, deployment related factors have been investigated (7). However, the increased prevalence (as well as severity) of general health symptoms does not appear to be unique to deploying populations either in terms of a particular symptom cluster or hazardous exposure other than the major threat that combat entails (12). An important concern for veterans is that these symptoms may be indicative of serious debilitating disease caused by toxic environmental exposures or vaccinations. Nonetheless, to date, in both the Gulf War 1990-91 and the Iraq conflicts, no specific association has been established despite extensive epidemiological research (3, 13). Specifically, no conclusive study has been able to identify a direct association between clinically diagnosed physical conditions including mTBI and increased symptom reporting, in the more recent conflicts (14).

Research does, however, suggest a strong link between increased symptom reporting and various psychological disorders including PTSD, anxiety and depression (10). The evidence suggests that pre-deployment anxiety disorders are predictive of increased post-deployment symptom reporting (5, 15).

10.2 Measures

The primary outcome of interest in this chapter is somatic symptom reporting, which was measured in the self-report questionnaire (see Appendix C). At both pre- and post-deployment, participants were asked to identify whether they had experienced any of 67 symptoms and if, they had, how severe they perceived the symptom to be (mild, moderate or severe).

10.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and changes in symptoms reporting from pre- to post-deployment?
- 2. Is there an association between **roles on most recent deployment** and changes in symptom reporting from pre- to post-deployment?
- 3. Is there an association between number and type of **traumatic deployment experiences** while on most recent deployment, and a change in symptom reporting from pre- to post-deployment?
- 4. Is there an association between **total length of time spent on deployment** in the previous three years and a change in symptom reporting from pre- to post-deployment?
- 5. Is there an association between the **number of previous deployments** and a change in symptom reporting from pre- to post-deployment?
- 6. Is previous **combat exposure** associated with changes in symptom reporting from pre- to post-deployment?
- 7. Is there an association between the **psychological co-morbid groups at post-deployment** and number of symptoms at post-deployment?

10.2.2 Sample Sizes

The total sample size used to compare the prevalence of pre-deployment symptom reporting for pre-deployment only participants, with pre- and post-deployment participants, was 506. Of the 547 participants who completed a pre-deployment questionnaire only, 41 participants did not fully complete the symptom reporting measure and were excluded from the analyses.

The total sample size used **to identify change in symptom reporting between preand post-deployment** was 1,065. Of the 1,324 participants who completed a preand a post-deployment questionnaire, one participant did not answer and 190 participants did not fully complete the symptom reporting measure at predeployment. A further 38 participants did not complete the measure at postdeployment and 30 did not fully complete it at either pre- or the post-deployment. Data from these participants were excluded from the analyses.

There may also be some variation to the sample sizes used for specific analyses due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

10.2.3 Data Analysis

A mixed model for repeated measures was used to analyse the number of symptoms reported. This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post-deployment) and their interaction(s) are included as fixed effects in the model.

When the outcome was the number of symptoms at post-deployment, a general linear model was used. The predictor of interest in this model was co-morbidity at post-deployment.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In

addition, the small numbers in some of the sub-groups may mean that there is insufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years).

10.3 Results

A comparison of the mean number of symptoms reported by respondents who completed the 67 item questionnaire at pre-deployment only and those who completed the questions at pre- and post-deployment was undertaken Table 10.1 (Appendix Q). The difference between the mean number of somatic symptoms reported at pre-deployment was not significant (p=0.43) for respondents who only completed a pre-deployment survey compared to those who completed both a pre- and post-deployment survey.

In addition, the proportion of respondents with each of the 15 most common symptoms reported by the pre- post-deployment sample at pre-deployment was compared between those who completed the pre-deployment questionnaire only and those who completed both the pre- and post-deployment questionnaire (Table 10.2, Appendix Q).

10.3.1 Analyses of Pre- Post- Sample

For respondents who completed the 67 item questionnaire at both pre- and postdeployment, the mean number of symptoms reported were 7.0 and 9.6 respectively (change = 2.6, 95% CI 2.2, 3.1) (Figure 10.1), and this change was significant (p< 0.0001) (Table 10.3, Appendix Q).



Figure 10.1: Distribution of change in mean number of somatic symptoms between pre- and post-deployment.

For respondents who completed both the pre- and post-deployment questionnaire, the top 15 most common symptoms at pre-deployment are presented in Table 10.4 (Appendix Q), and the top 15 most common symptoms at post-deployment are presented in Table 10.5 (Appendix Q).

The 15 symptoms that **increased the most** between pre- and post-deployment, reported are presented in Table 10.6. It should be noted that these symptoms have significant overlap with those contained in the scales measuring psychological distress.

Symptoms	Yes Pre- (%)	Yes Post- (%)	Diff (Post-Pre) (%)
Sleeping difficulties	36.4%	52.1%	15.7%
Feeling jumpy / easily startled	9.8%	25.0%	15.2%
Irritability / outbursts of anger	31.4%	46.4%	15.0%
Feeling distant or cut off from others	14.4%	26.4%	12.0%
Avoiding doing things or situations	11.1%	21.6%	10.5%
Loss of concentration	16.1%	26.1%	10.0%
Ringing in the ears	15.3%	25.1%	9.8%
Increased sensitivity to noise	5.6%	15.1%	9.5%
Forgetfulness	17.8%	27.0%	9.2%
Feeling unrefreshed after sleep	39.8%	48.9%	9.1%
Difficulty finding the right word	20.7%	28.8%	8.1%
Unintended weight gain greater than 4kg	7.1%	14.6%	7.5%
Distressing dreams	8.9%	15.5%	6.6%
Intolerance to alcohol	6.1%	12.3%	6.2%
Low back pain	32.4%	38.6%	6.2%

Table 10.6: Top 15 increased symptoms between pre- and post-deployment

10.3.2 Length of Recent Deployment

The means for the association between length of recent deployment and changes in number of symptoms reported are presented in Table 10.7.

Length of most recent deployment (months)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
≤5 months	323	7.96	8.92	0.96
		(6.85, 9.06)	(7.62, 10.21)	(0.03, 1.89)
6 or 7 months	322	8.09	11.83	3.74
		(6.87, 9.32)	(10.44, 13.23)	(2.81, 4.67)
8 months	229	6.88	9.43	2.55
		(5.50, 8.27)	(7.84, 11.03)	(1.44, 3.66)
9-12 months	191	7.48	11.27	3.77
		(6.06, 8.91)	(9.59, 12.93)	(2.56, 4.99)

As can be seen in Table 10.7, the increase in the number of symptoms reported between pre- and post-deployment was greater on average for those who had been deployed for 6 or 7 months (p<0.0001) or 9-12 months (p=0.0003), than for those who had been deployed for less than or equal to 5 months. This association is illustrated in Figure 10.2.



Figure 10.2: Mean change in symptoms reported for each category of recent deployment length.

Role on recent	Ν	Pre-deployment	Post-deployment	Change
deployment		(95% CI)	(95% CI)	(95% CI)
Combat Afghan &	563	9.43	13.10	3.67
Outside MSB		(7.91, 10.96)	(11.49, 14.71)	(2.96, 4.37)
Inside MSB	242	8.37	10.71	2.34
		(6.93, 9.81)	(9.08, 12.34)	(1.27, 3.42)
Outside Afghan	260	7.38	8.09	0.73
		(6.18, 8.55)	(6.70, 9.49)	(-0.31, 1.76)

Table 10.8: Mean (95% CI) number of symptoms reported for each role on recent deployment

As can be seen in Table 10.8, the increase in the number of symptoms reported between pre- and post-deployment was greater on average for those whose role was Combat Afghan & Outside MSB compared to those whose role was Inside MSB (p=0.04), and those who were Outside Afghan (p<0.0001). The change was also greater for those Inside MSB compared to those Outside Afghan (p=0.03) (see Figure 10.3).



Figure 10.3: Mean number of symptoms reported for each role on recent deployment

10.3.4 Number of Traumatic Deployment Exposures

Associations between number of traumatic deployment exposures and changes to the number of symptoms reported between pre- and post-deployment (n = 1032) are presented in Table 10.9.

Deployment exposure (category)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
Low	280	7.63	7.99	0.36
		(6.48, 8.77)	(6.65, 9.33)	(-0.62 <i>,</i> 1.35)
Medium	232	8.34	11.36	3.02
		(6.97, 9.72)	(9.79, 12.93)	(1.94, 4.10)
High	259	8.33	11.57	3.24
		(6.73, 9.93)	(9.82, 13.32)	(2.21, 4.26)
Very High	261	9.75	13.77	4.02
		(8.11, 11.40)	(11.98, 15.57)	(3.01, 5.04)

Table 10.9: Mean	i (95% CI) numbei	of symptoms reported for	r each deployment exp	posure category
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As can be seen in Table 10.9, the change in number of symptoms reported was significantly different between the four categories of deployment exposure (p<0.0001). Compared to respondents with a low number of deployment exposures, those with medium (p=0.0004), high (p<0.0001) and very high (p<0.0001) numbers reported significantly greater increases in symptoms between pre- and post-deployment (see Figure 10.4).



Figure 10.4: Mean number of symptoms reported at for each deployment exposure category

10.3.5 Traumatic Deployment Experiences

The proportions of respondents who indicated at least one exposure to each of the nine categories of deployment experiences (1032) are summarised in Table 10.10, along with associated change in number of symptoms reported between pre- and post-deployment. Note that each respondent could have responded positively to more than one deployment experience.

Deployment experiences	Exposed		Unexposed		Difference
	N (%)	Change number of symptoms (95% CI)	N (%)	Change number of symptoms (95% CI)	P value
Coming under fire	764 (74.1%)	3.35 (2.75, 3.95)	267 (25.9%)	0.47 (-0.54, 1.48)	p<0.0001
Vulnerable situations or fear of events	732 (70.9%)	3.45 (2.84, 4.06)	300 (29.1%)	0.55 (-0.40, 1.50)	p<0.0001
Casualties among those close to you	636 (61.9%)	3.63 (2.97, 4.28)	392 (38.1%)	0.89 (0.06, 1.72)	p<0.0001
In danger of being killed/injured	505 (49.1%)	3.83 (3.10, 4.57)	524 (50.9%)	1.39 (0.67, 2.11)	p<0.0001

Table 10.10: Percentage of respondents exposed to each experience,	and associated change in
number of symptoms reported.	

Seeing/handling	510	3.67	517	1.51	p<0.0001
dead bodies	(49.7%)	(2.94, 4.40)	(50.3%)	(0.79, 2.24)	
Discharging own	286	3.75	744	2.17	p=0.05
weapon	(27.8%)	(2.35 <i>,</i> 5.15)	(72.2%)	(1.30, 3.03)	
Unable to respond	208	3.89	820	2.27	p=0.01
to a threatening	(20.2%)	(2.74, 5.05)	(79.8%)	(1.69, 2.85)	
situation					
Human	131	5.93	895	2.09	p<0.0001
degradation	(12.8%)	(4.49 <i>,</i> 7.37)	(87.2%)	(1.54, 2.64)	
Actions resulting in	80	2.19	948	2.62	p=0.67
injury or death	(7.8%)	(0.32 <i>,</i> 4.05)	(92.2%)	(2.07, 3.16)	

Coming under fire, exposure to vulnerable situations or fear of events and casualties among those close to you, were the most common deployment experiences reported by respondents. Respondents who reported all deployment exposures other than actions resulting in injury or death had greater increases in the number of symptoms reported between pre- and post-deployment than respondents who did not report these exposures.

10.3.6 Number of Prior Deployments

The means for the association between prior deployments and changes to number of symptoms reported (n = 974) are presented in Table 10.11 (Appendix Q). The increase in symptoms reported between pre- and post-deployment was not significantly different between the four different categories of prior deployments.

10.3.7 Total Time on Deployment in Previous Three Years

The means for the association between total time on prior deployments in the past three years and changes to number of symptoms reported (n = 793) are presented in Table 10.12 (Appendix Q). The increase in symptoms reported between pre- and post-deployment was not significantly different between the four different categories of total time on deployments over the last three years.

10.3.8 Previous Combat Exposure

The means for the association between previous combat exposure and changes to the number of symptoms reported between pre- and post-deployment (n = 1028) are presented in Table 10.13 (Appendix Q). The change in number of symptoms reported between pre- and post-deployment was not significantly different between those who did and did not report previous combat exposure.

10.3.9 Psychological Co-Morbidity

An analysis of the 15 most common symptoms reported at post-deployment for each of the four co-morbidity groups (none, one, two and three) was also undertaken (Tables 10.14, 10.15, 10.16 and 10.17, Appendix Q).

Using the 15 most common symptoms reported at post-deployment, Table 10.18 presents a comparison of the proportion of respondents within each co-morbidity group who reported each somatic symptom.

	No Psychological	One Psychological	Two Psychological	Three Psychological
Symptom	Conditions	Condition	Conditions	Conditions
Sleeping difficulties	38.6%	58.0%	81.9%	94.4%
Feeling unrefreshed				
after sleep	32.5%	59.9%	77.9%	97.2%
Fatigue	32.2%	55.1%	78.4%	98.6%
Headaches	30.5%	39.5%	62.8%	76.4%
Irritability / outbursts of				
anger	27.9%	53.8%	79.9%	94.4%
Low back pain	27.5%	44.0%	56.7%	71.2%
General muscle aches or				
pains	21.0%	42.7%	46.6%	60.3%
Ringing in the ears	19.2%	24.1%	48.0%	54.2%
Joint stiffness	15.4%	26.4%	40.7%	57.5%
Forgetfulness	15.3%	26.9%	53.3%	75.3%
Difficulty finding the				
right word	14.7%	33.0%	53.3%	80.8%
Flatulence or burping	13.7%	22.8%	29.5%	54.2%
Feeling jumpy / easily				
startled	11.6%	22.7%	57.7%	79.2%
Loss of concentration	11.1%	30.0%	58.0%	86.3%
Diarrhoea	11.0%	17.1%	24.7%	41.1%

 Table 10.18: Percentage of respondents in each co-morbid group who reported the 15 most

 common symptoms for those responders who had no psychological conditions at post-deployment

As presented in Table 10.18, the percentage of respondents reporting each of the 15 somatic symptoms increased with greater numbers of co-morbidities. The largest percentages were for respondents with three co-morbid psychological conditions at post-deployment. While a slightly smaller percentage of those with two co-morbid psychological conditions reported each symptom, this was still larger than the percentage of respondents with one or no psychological conditions.

Table 10.19 shows the mean number of somatic symptoms at post-deployment for the different categories of co-morbidity at post-deployment.

Co-morbidity category	N	Mean No. Symptoms at Post- Deployment (95% CI)
None	667	6.0 (4.9, 7.1)
1 co-morbidity	384	11.0 (9.7, 12.3)
2 co-morbidities	160	18.8 (17.2, 20.5)
3 co-morbidities	72	28.3 (26.1, 30.5)

Table 10.19: Mean number of symptoms reported for each co-morbidity category

As presented in Table 10.19, there were significant differences between all comorbidity categories, in the number of somatic symptoms reported at postdeployment (p = <.0001). With each increase in number of psychological conditions, there was a corresponding increase in the number of symptoms reported at postdeployment. The greatest number of symptoms was observed for those with three psychological co-morbidities (see figure 10.5).



Figure 10.5: Mean number of symptoms reported for each co-morbid group

10.4 Summary of Results

Table 10.20 summarises the key findings presented in this results section in relation to the questions posed in section 10.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Length of most recent deployment	Compared to those away for ≤ 5 months, those away for 6 to 7 months and 9 to 12 months were likely to have a greater increase between pre- and post-deployment in number of symptoms reported.
Q2. Role on most recent deployment	The increase in number of symptoms reported between pre- and post-deployment was greater for those in a combat role or who operated outside a main support base, and for those whose role was inside a main support base, compared to those who were Outside Afghan.
Q3a. Number of traumatic deployment exposures	Compared to respondents with a low number of deployment exposures, those with medium, high and very high numbers reported significantly greater increases in number of symptoms between pre- and post-deployment.

Q3b. Traumatic deployment experiences	Respondents who reported any deployment exposures, apart from actions resulting in injury or death, had greater increases in the number of symptoms reported between pre- and post-deployment, compared to respondents who did not report them.
Q4. Number of prior deployments	Nil
Q5. Total time on prior deployments	Nil
Q6. Previous combat exposure	Nil
Q7. Psychological co-morbidity at post-deployment	The percentage of respondents reporting each of the 15 most common somatic symptoms at post-deployment increased with greater number of psychological conditions.
	With each increase in number of psychological conditions, there was a corresponding increase in the number of symptoms reported at post-deployment. The greatest number of symptoms was observed for those with three psychological co-morbidities.

10.5 Discussion

The overall mean number of somatic symptoms for participants who completed both the pre- and post-deployment 67 item questionnaire was 7.0 at pre-deployment and 9.6 at post-deployment and this change was statistically significant. However, both the pre- and post-deployment mean 67 item scores were lower than the mean number of somatic symptoms (13) reported by participants who deployed to Afghanistan in the recently completed MEAO Census Study (16). As there was often a considerable lag time between deployment and completing the MEAO Census Study questionnaire, this finding raises the possibility that levels of somatic distress may only increase with the passage of time.

Similar to the MEAO Census Study (16), and the Millennium Cohort Study (17) the most commonly reported symptoms at both pre- and post-deployment pertained to fatigue and sleep (fatigue, feeling unrefreshed after sleep and sleeping difficulties). Apart from 'feeling jumpy/easily startled', which only appeared in the list at post-deployment, and 'flatulence or burping', which only appeared in the list at pre-deployment, symptoms which were included in a list of 15 most common somatic symptoms reported at pre- and post-deployment were very similar. Importantly, these symptoms are generally those that would be anticipated to arise as a consequence of central information processing and sensory filtering systems. These are also the domains are known to be impacted by combat exposure (18) and related psychological disorders that emerge due to trauma exposure.

10.5.1 Associations with Somatic Symptoms at Pre- and Post-Deployment

Associations between a number of factors and reporting of somatic symptoms were found. These factors included the length of most recent deployment, role type on most recent deployment and the number as well as type of traumatic deployment experiences. In addition, an association was found between the number of somatic symptoms reported and psychological co-morbidity at post-deployment. While this suggests that there are substantial commonalities between the underlying factors
that increase somatic and psychological distress, the complexity of the mechanisms underpinning this association should not be underestimated nor assumed (19).

10.5.2 Length of Most Recent Deployment

The association between length of most recent deployment and a change in the number of reported somatic symptoms was statistically significant. Those respondents who were away for six to seven months and those who were away for at least nine months reported a greater increase in somatic symptoms between preand post-deployment, compared to those who were away for five or fewer months. This supports the findings of a number of other studies that have identified a statistically significant association between a greater number of mental and physical health complaints and longer deployment length (20-22).

In contrast, the change in number of symptoms reported for respondents in this study who were away for eight months was not significantly different from those who were away for five or fewer months. Similarly, while increased psychological distress was found to be associated with being away for six to seven months and nine or more months, it was not found for respondents deployed for eight months (see Chapter 5). This suggests that the respondents who were away for eight months, compared to those away for six to seven or, nine or more months, may be somehow different. A non linear association between time away on deployment and the reporting of physical and mental symptoms has also been found by Buckman et al (23) They suggested that there was a ceiling effect, whereby deployment per se was not a significant stressor, providing military personnel did not deploy for more than six months at a time and/ or for more than 12 months in any given three year period.

Nevertheless, many studies (24-27) have found deployment in general to be associated with increased prevalence and severity of multiple self reported symptoms. A study involving US Gulf War veterans reported both a higher prevalence and a greater severity of multi somatic symptoms, and this finding persisted over time (28). For example, US Gulf War veterans from all three military services who reported multiple symptoms including back pain, feeling tired and being anxious in 1991 (29) also reported similar medically unexplained symptoms fourteen years later (6).

Comparable evidence was also documented for UK military personnel in a study conducted seven years after the end of the Gulf War 1990-91. This investigation identified seven symptom clusters, which were common to both members deployed to the Gulf War and those who were not (30), the only difference being a significantly higher severity of symptoms reported by members of the deployed cohort (31).

Consistent with studies conducted in the US and the UK, the Australian Gulf War Study found deployed veterans reported a greater number of symptoms, including feeling unrefreshed after sleep, fatigue, headaches, sleeping difficulties, irritability/outbursts of anger, low back pain, general muscle aches or pains, flatulence or burping, forgetfulness, and difficulty finding the right word, more frequently and with greater severity than a non deployed comparison groups (32). While a greater number of symptoms were reported, a factor analysis did not suggest a unique pattern of symptoms among Australian Gulf War veterans. Unlike Gulf War veterans (7), UK military personnel deployed to Iraq in 2003 did not have a substantially increased level of symptom reporting in comparison to a non deployed group (33). In fact, two of the symptoms (joint pain and stiffness) were found to be less common in the deployed population compared to non-deployed.

10.5.3 Role on Most Recent Deployment and Traumatic Deployment Experiences

In this study, those who were in a combat role and those who worked primarily outside the main support base reported the greatest increase in the number of somatic symptoms. Likewise, greater numbers of trauma exposures were also significantly associated with greater increases in the number of somatic symptoms reported between pre- and post-deployment.

Other studies have also found combat roles to be significantly associated with high levels of somatic symptoms after deployment. For example, a study involving UK military who had deployed to Iraq found that the time spent within a designated combat area partly explained the previously discussed association between time spent away on deployment and physical symptoms (20). High combat exposure in itself has also been found to be directly associated with chronic multi symptom illness among deployed veterans (5). A study (34) involving Gulf War 1990-91 veterans and a control group of military personnel who served elsewhere, found that veterans who served in Iraq and/or Kuwait had the highest rate of multi symptom illness. Again, these were thought to be the areas most associated with increased fighting and battle exposures. This study also found that veterans who were stationed in support areas reported fewer somatic symptoms. The authors suggested that a greater number and/or concentration of traumatic exposures or experiences were likely to occur within these areas, which in turn accounted for the increase in symptom reporting. Rather than combat exposure itself, King et al (35) identified that the perception of a traumatic experience on deployment, including being within a threatening situation, was significantly associated with the number of self reported somatic symptoms at post-deployment.

These findings suggest that somatic distress is a correlate of exposure to the stress and psychological threat of potential combat exposure. Many veterans may primarily present with these symptoms rather than psychological complaints and it is important to be aware of this potential origin of somatic symptoms, particularly in primary care settings.

10.5.4 Psychological Co-morbidity

Studies have also repeatedly identified a strong association between multi-symptom illness and psychological disorders (5). However the complexity of this relationship and the nature of mechanisms linking these separate dimensions of distress should not be underestimated (10). In the current study, being at risk of three co-morbid psychological conditions was associated with a greater number of somatic symptoms at post-deployment. An early study by Unwin et al (27) found that for Gulf War veterans, multi symptom illness was associated with PTSD, independent of somatic or psychiatric distress, health impairment, and sub traumatic stress (15). Likewise Gulf War Veterans who screened positive for PTSD were significantly more likely to also report a higher number of somatic symptoms (36). In the Australian Gulf War study, participants with multi symptom illness had a higher prevalence of psychiatric disorders, including major depression and PTSD, compared to veterans without multi symptom illness. This association was consistent whether or not they had deployed to the Gulf War (32), suggesting that this is not a deployment specific effect. A strong association between PTSD and increased reporting of physical symptoms was also noted in a study involving US veterans returning from Iraq (37).

In essence, while the roles that traumatic distress and PTSD play in the development of multi symptom illness are well documented (19), it should be restated that psychological disorders alone do not account for the development of all multisymptom presentations (38). Instead, research now suggests that common neurobiological mechanisms, shared, in part, with psychiatric disorders, may underpin the development of a multi-symptom illness (10, 39). Future chapters in this report including Chapter Eleven (mTBI), will therefore examine the extent to which somatic symptoms are associated with a range of other psycho-physiological outcomes.

10.6 Summary

This study has shown that there was a significant increase in the average number of somatic symptoms between pre- and post-deployment. In addition, the results in this chapter demonstrate that this increase was associated with a number of factors related to the most recent deployment. The increase in the number of symptoms reported was greatest on average for those respondents who were away on the most recent deployment for between six to seven months or between nine to twelve months, for those in a combat role or who worked outside of the main support base, and those who reported being exposed to a traumatic deployment event. In addition, the findings in this chapter show that the group of participants who met the criteria for three co-morbid psychological conditions at post-deployment not only reported the greatest number of somatic symptoms, but were also more likely to report each of the top 15 somatic symptoms reported at post-deployment.

This was the first chapter in the section relating to Physical Health. Section Three continues by presenting and discussing the findings in relation to mTBI. Also included within Section Three are:

- **mTBI** in Chapter Eleven
- Cardiovascular Health in Chapter Twelve
- **Respiratory Health** in Chapter Thirteen
- Skin Conditions in Chapter Fourteen

Further sections within this report focus on:

- Biomedical Markers in Section Four
- Social Health in Section Five
- Identifying Possible Risk Markers in Section Six
- **Conclusions and Limitations** are presented in Chapter Twenty Two

10.7 Other Chapters of Relevance

• Chapter Twenty One – Allostatic Load

10.8 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

• Is there an interaction between the various deployment-related factors, age and prior exposures, on somatic symptom reporting?

- What factors are associated with different trajectories of somatic symptom reporting (decreasing, stable and increasing symptoms) between pre- and post-deployment?
- What is the impact of the pre-deployment symptom interpretation questionnaire, on the pattern of somatic symptom reporting?
- Are there particular exposures, risk factors and deployment histories associated with somatic symptoms reported at post-deployment?
- What are the potential reasons for variations in psychological distress between groups with different deployment lengths? In particular, what might set apart those that were deployed for 8 months in comparison to those that were deployed for 6 to 7 months and 9 to 12 months.
- Are there any chemical and/or environmental exposures on the most recent deployment that are associated with somatic symptoms reported at post-deployment?

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Chapter Eleven – Mild Traumatic Brain Injury

Key Points

- 1. An analysis of the self-report data showed that 26.9% of participants reported meeting the criteria for **lifetime mTBI** at pre-deployment and 9.3% of participants reporting the criteria for **a new mTBI** at post-deployment.
- 2. New mTBIs were significantly associated with several factors connected to the **most recent deployment**.
 - being in a combat role or operating outside of the main support base,
 - reporting a number of different traumatic deployment experiences; and
 - reporting a high (17 to 35) or very high number (>35) of deployment exposures.
- 3. No significant associations were found between a new or lifetime mTBI and factors associated with prior deployments.
- 4. Reporting either a new or lifetime mTBI was also associated with:
 - Increases in PTSD symptoms between pre- and post-deployment; and
 - Meeting criteria for at least two co-morbid psychological conditions at post-deployment.

This chapter presents and discusses the findings relating to mTBIs which have been reported at pre- and/or post-deployment. The chapter begins by briefly discussing current literature. Primary results are then provided, beginning with a comparison of the number of mTBIs reported at pre-deployment by responders who only completed a pre-deployment questionnaire, and those responders who completed both a pre- and post-deployment questionnaire. All subsequent analyses within the result section include only those participants who completed both the pre- and post-deployment measures. The chapter concludes by discussing the primary findings pertaining to mTBIs.

11.1 Introduction

There has been a longstanding debate, going back to World War I, about the role that blast exposures play in subsequent psychological sequelae and the role of concussive blast in symptomatic morbidity. Due to the emergence of improvised explosive devices by insurgents as a primary weapon in the MEAO, this debate has re-emerged. Two critical questions are at the forefront of recent studies into mTBI. The first relates to whether long-term symptoms of post-concussion syndrome are indicative of subtle neurological effects of mTBI, or are accounted for by the associated psychological consequences of exposure to the threat inherent in blast exposure, and their neurobiological underpinnings. As neurocognitive abnormalities are well characterised in PTSD, these deficits following mTBI cannot simply be seen as being due to neurological damage of blast injury. A related issue which has

received considerable attention in the civilian literature is the role that mTBI/loss of consciousness plays in the onset and course of PTSD. These relationships are difficult to disentangle even in longitudinal studies. A distinct advantage of a prospective study design is that the pre-deployment injuries and a base line of cognitive functioning can be documented.

The second issue emerging from more recent studies pertains to the determination of accurate mTBI prevalence rates. Inconsistencies in how mTBI is defined may contribute to this. For example, some studies include post-concussive symptoms in their definition (1), while others do not (2). Where post-concussive symptoms are included, they are largely non-specific and may or may not be directly attributable to the head injury (3-5) as many of these symptoms are shared with PTSD and depression.

In this chapter, mTBI refers to an event in which the head is physically injured, and is characterised by the immediate symptoms of loss of consciousness, altered mental status, and/or post-traumatic amnesia (2). It may or may not result in post-concussive symptoms that can occur following mTBI, including problems with memory, balance, concentration, headache, tinnitus, sensitivity to light, fatigue, and irritability among others (2, 6)

MilHOP is the first research program to investigate mTBI in a serving Australian military population. Up until now, the vast majority of mTBI research in military populations has emerged from the US, with limited research also emanating from the UK and Canada. Rates of mTBI in US military personnel deployed to the MEAO are estimated to be between 12% and 20% (2, 7, 8). Lower rates have been reported for UK and Canadian military personnel returning from deployment to the MEAO (4.% and 6.8% respectively) (9, 10).

Research in these military populations has found that deployment and associated combat exposure are related to an increased incidence of mTBI. While Cameron et al. (11) found that the incidence of mTBI was generally higher in US military personnel who had recently deployed, Rona et al. (9), not surprisingly, identified that rather than deployment per se, deployment length and acting in a combat role were more likely to be associated with any increase in rates of mTBI. Similarly, Zamorski et al. (10) found that mTBI was most often reported by those Canadian personnel with greater combat experience.

Research has failed thus far to examine the impact of *multiple* mTBIs in deployed military personnel (12). However, studies examining the impact of multiple mTBIs in sporting samples have found evidence of cumulative impairment (13). In a prospective study of US college athletes, for instance, Slobounov et al. (14) found that while neither post-concussive symptoms nor neurological deficits were present in the final 7 day follow-up, brain functioning decreased for those athletes who had experienced a second mTBI. In addition, a shorter time between the first and second head injury resulted in a slower rate of recovery. These deficits were observed even without any noticeable symptoms.

There are a number of risk factors and individual vulnerabilities that may predispose individuals to poorer outcomes following mTBI. Pre-morbid and co-morbid psychiatric problems are likely predictors of increased post-concussive symptoms (2, 15, 16). Again, it should be noted that many of the post-concussive symptoms associated with mTBIs such as difficulties concentrating, irritability and headaches could also be attributed to a number of psychiatric conditions including PTSD. Likewise, events that

lead to the physical head injury could also independently cause significant psychological distress.

11.2 Measures

The mTBI screening questions used in this chapter (see Appendix C) were based on the measures utilised by Hoge, McGurk et al. (2). This measure, included within the self-report questionnaire, was chosen, despite its limitations, so that comparisons could be made with the studies of our major allies who have also used this instrument. At pre-deployment, a positive screen for 'lifetime mTBI' required the participant to have reported experiencing one of the following events at some point in their lifetime. At post-deployment, a positive screen for any 'new mTBI' required the participant to have reported experiencing one of the following events since the beginning of their most recent deployment:

- "Blast or Explosion IED (improvised explosive device)",
- "RPG (rocket propelled grenade)",
- "Land mine, Grenade, etc.",
- "Vehicular accident/crash (any vehicle, including aircraft)",
- "Fragment wound or bullet wound above the shoulders",
- "Fall";

In addition, at least one of the following symptoms must have been experienced immediately after the event:

- "Loss of consciousness/'knocked out',
- "Being dazed, confused, or 'seeing stars'; and/or
- "Not remembering the event".

Please note: the mTBI measure does not capture the number of lifetime and/or new mTBIs incurred. The results presented in this chapter represent the number of people who reported at least one mTBI at pre-deployment (lifetime), the number who reported at least one mTBI at post-deployment (new), and the number of people who reported an mTBI at both pre- and post-deployment.

11.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. What is the **prevalence** of lifetime and new post-deployment mTBI?
- 2. Is there an association between **length of most recent deployment** and new post-deployment mTBI?
- 3. Is there an association between **roles on most recent deployment** and new post-deployment mTBI?
- 4. Is there an association between the type of **traumatic deployment experience** while on most recent deployment, and new post-deployment mTBI?
- 5. Is there an association between **total length of time spent on deployment** in the previous three years and new post-deployment mTBI?
- 6. Is there an association between the **number of previous deployments** and new post-deployment mTBI?
- 7. Is previous combat exposure associated with new post-deployment mTBI?

- 8. Is there an association between **changes in PTSD symptoms** from pre- to post-deployment and reporting a new post-deployment mTBI?
- 9. Is there an association between lifetime mTBI and **changes in PTSD symptoms** from pre- to post-deployment?
- 10. Is there an association between new mTBIs and the **psychological comorbid groups** at post-deployment?
- 11. Is there an association between lifetime mTBI and the **psychological comorbid groups** at post-deployment?

11.2.2 Sample Sizes

The total sample size used **to examine mTBI at pre- and post-deployment** was 1,295. Of the 1,324 participants who completed both a pre- and a post-deployment self-report questionnaire 29 were excluded - 17 participants did not complete the mTBI measure at pre-deployment, and 12 did not complete it at post-deployment.

The total sample size used **to compare pre-deployment lifetime mTBI** for predeployment only participants, with pre- and post-deployment participants, was 539. (8 participants did not complete the mTBI measure at pre-deployment).

There may also be some variation to the sample sizes used for specific analyses due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

11.2.3 Data Analysis

For the purposes of modelling, two outcomes are considered. Participants were categorised as having a lifetime mTBI, or not, at pre-deployment, and a new mTBI or not, at post-deployment. These were then each used as two level categorical outcomes in a binary logit model. This approach allowed for the associations between the predictors of interest, and incidence of lifetime and new mTBI to be examined

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

11.3 Results

The same mTBI self-report screening questions were used in both the pre- and postdeployment questionnaire. The questions in the pre-deployment questionnaire referred to lifetime mTBI, while the questions at post-deployment referred to mTBI incurred since the beginning of the most recent deployment.

A comparison of the proportion of respondents who completed the mTBI questions at pre-deployment only, and those who completed the questions at pre- and post-deployment was undertaken (Table 11.1, Appendix R).

11.3.1 Analyses of Pre- Post- Sample

For respondents who completed the mTBI questions at both pre- and postdeployment, 26.9% reported a lifetime mTBI at pre-deployment. At post-deployment 9.3% of these respondents reported a new mTBI, and only 3.6% of respondents who reported an mTBI at pre-deployment reported a new mTBI at post-deployment. A summary of these results is presented in Table 11.2. Results by sub-sample are provided in Table 11.3 (Appendix R).

Pre-	Reported mTBI			
Post- Total N	Neither N (%)	At Pre- Only N (%)	At Post- Only N (%)	At Both N (%)
1295	873 (67.4%)	302 (23.3%)	73 (5.7%)	47 (3.6%)

The types of injuries reported by respondents with a lifetime mTBI compared to a new mTBI are presented in Table 11.4. For respondents who reported a lifetime mTBI at pre-deployment, the most common injury mechanisms were vehicular accidents and falls. For those who reported a new mTBI the most common injury mechanisms were deployment related, and included blasts or explosions, and RPG, land mine or grenades, although a large proportion also reported falls. A summary of these results is presented in Table 11.4.

Table 11.4: Percentage	of participants with	lifetime and new r	mTBI for each	type of injury.
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Type of Injury	Lifetime mTBI reported at pre-deployment N (%)	New mTBI reported at post-deployment N (%)
Blast or Explosion IED	60 (17.2%)	83 (69.2%)
RPG, Land Mine, Grenade etc	65 (18.7%)	74 (62.2%)
Vehicular accident/crash	270 (77.6%)	42 (35.3%)
Fragment wound or bullet wound above the shoulders	11 (3.2%)	3 (2.5%)
Fall	252 (72.4%)	67 (55.8%)

The types of symptoms reported by respondents with a lifetime mTBI compared to a new mTBI are presented in Table 11.5. Being dazed, confused, or seeing stars was the most commonly reported symptom for respondents who reported a lifetime or a new mTBI. Overall, respondents with a lifetime mTBI appeared to report a greater variety of symptoms compared to those with a new mTBI. For those who reported a lifetime mTBI, 61.7% reported losing consciousness or being knocked out, and 58.9% reported being concussed. In contrast, only 30% of respondents with a new mTBI reported loss of consciousness, and 20.7% reported concussion. A summary of these results is presented in Table 11.5.

Type of Symptom	Lifetime mTBI reported at pre-deployment N (%)	New mTBI reported at post-deployment N (%)
Loss of consciousness/knocked Out	208 (61.7%)	35 (30.2%)
Being dazed, confused, or seeing stars	270 (79.4%)	96 (82.1%)
not remembering the event	126 (38.5%)	30 (26.5%)
Concussion	196 (58.9%)	24 (20.7%)
Head Injury	158 (47.7%)	26 (23.0%)

Table 11.5: Percentage of participants with lifetime and new mTBI for each type of symptom.

11.3.2 Length of Recent Deployment

Table 11.6 (Appendix R) shows the percentage of participants with and without a new mTBI for the different 'Length of recent deployment' categories. Using '<=5 Months' as the predictor reference, there was no significant association between length of recent deployment and new mTBI, reported at post-deployment.

11.3.3 Role on Most Recent Deployment

Table 11.7 shows the percentage of participants with and without a new mTBI reported, for the different 'Role on recent deployment' categories.

Table 11.7: Percentage of participants with and without new mTBI for each role on recent deployment.

Role on recent deployment	N	New post- deployment mTBI
Combat Afghan & Outside MSB	669	14.8%
Inside MSB	293	4.4%
Outside Afghan	333	2.4%

Using 'Outside Afghan' as the predictor reference, there was a significant association between role on most recent deployment and new mTBI (p<0.0001). As can be seen in Table 11.7, those respondents who were on a combat role in Afghanistan or who worked outside the main support base were significantly more likely to report a new mTBI at post-deployment, compared to those who were in non-combat roles outside Afghanistan (p=0.0003, OR=6.54, 95% CI 2.35, 18.24).

The significant association between role on recent deployment and reporting a new mTBI is illustrated in Figure 11.1.





11.3.4 Number of Traumatic Deployment Exposures

The percentage of participants with and without a new mTBI at post-deployment, for each number of deployment exposures are presented in Table 11.8.

Table 11.8: Percentage of participants with and without new mTBI for each deployment exposu	re
category	

Deployment exposure (category)	N	New post- deployment mTBI
Low	358	2.2%
Medium	273	2.9%
High	307	8.1%
Very High	309	22.7%

Using 'Low exposures' as the predictor reference, there was a significant association between number of deployment exposures and new mTBI (p<0.0001).

Those respondents who had high (p=0.001, OR=6.96, 95%CI 2.19, 22.09) and very high (p<0.0001, OR=22.72, 95%CI 7.26, 71.10) numbers of deployment exposures were significantly more likely to report a new mTBI at post-deployment compared to those who had the lowest number of exposures. This association is illustrated in Figure 11.2.





11.3.5 Traumatic Deployment Experiences

The proportion of respondents with and without a new mTBI at post-deployment, who indicated at least one exposure of the nine categories of deployment experiences (n = 1247) are detailed in Table 11.9 (Appendix R) summarised in Table 11.10. Note that each respondent could have responded positively to more than one deployment experience.

Deployment experiences	Exposed Vs Unexposed	
	OR (95 % CI)	Р
Coming under fire	4.79	p=0.001
	(1.85, 12.43)	
Vulnerable situations or fear of	3.63	p=0.002
events	(1.56, 8.66)	
Casualties among those close to you	11.10	p<0.0001
Casualties among those close to you	(4.54, 27.14)	
In danger of being killed /injured	3.81	p<0.0001
In danger of being kined/injured	(2.15, 6.76)	
Seeing/handling dead hodies	2.85	p<0.0001
	(1.69, 4.81)	
Discharging own weapon	2.48	p<0.0001
	(1.58, 3.89)	
Unable to respond to a threatening	2.48	p<0.0001
situation	(1.64, 4.01)	
Human degradation	2.39	p=0.0002
	(1.50, 3.80)	
Actions resulting in injury or death	3.59	p<0.0001
	(2.13, 6.06)	

Table 11.10: Percentage of respondents exposed to each experience with and without new mTBI.

Participants who reported exposure to any of the deployment experiences were significantly more likely to report a new mTBI at post-deployment, compared to those participants who did not report these experiences (Table 11.10).

11.3.6 Number of Prior Deployments

Table 11.12 (Appendix R) presents the percentage of participants with and without a new mTBI for the different 'Number of prior deployment' categories (n = 1173). Using 'None' as the predictor reference, there was no significant association between number of prior deployments and the risk for new mTBI reported at post-deployment, although a trend appeared to exist.

11.3.7 Total Time on Prior Deployments

11.3.7.1 Lifetime mTBI at Pre-Deployment

Table 11.13 (Appendix R) shows the percentage of participants with and without a lifetime mTBI for the different 'Total time on prior deployment' categories (n = 961). Using 'None' as the predictor reference, the association between total time on prior deployment and risk for lifetime mTBI at pre-deployment, was not significant.

11.3.8 Previous Combat Exposure

11.3.8.1 Lifetime mTBI at Pre-Deployment

Table 11.14 shows the percentage of participants with and without a lifetime mTBI at pre-deployment, for those who did, and did not report previous combat exposure (n = 1251).

Table 11.14: Percentage of participants with previous combat exposure, with and without lifetime mTBI.

Previous Combat Exposure	N	Lifetime Pre- deployment mTBI
Yes	179	41.3%
No	1072	24.8%

Those respondents who did report previous combat exposure, were more likely to report a lifetime mTBI at pre-deployment (OR = 2.029, 95% CI 1.43, 2.87) (figure 11.3)



Figure 11.3: Percentage of participants with and without prior combat exposure, with lifetime mTBI.

11.3.9 PTSD symptoms

11.3.9.1 Change in PCL-C scores and new mTBI

Table 11.15 shows the percentage of participants with and without a new mTBI at post-deployment for the different categories of change in PTSD symptoms (Increase, Decrease, No change) (n = 1224) between pre- and post-deployment.

Table 11.15: Percentage of participants with and without new mTBI for each category of PCL-Cchange.

Change in PCL-C	N	New post-deployment mTBI
PCL-C Increase	118	28.8%
PCL-C Decrease	21	9.5%
PCL-C No change	1085	7.0%

Compared to respondents whose PTSD symptoms did not change between pre- and post-deployment, respondents who had an increase in symptoms were significantly more likely to report a new mTBI at post-deployment (OR = 4.98, 95% CI 3.09, 8.04).



Figure 11.4: Percentage of participants with new mTBI for each category of PCL-C change

11.3.9.2 Lifetime mTBI at Pre-Deployment and Change in PCL-C scores

Table 11.16 shows the percentage of participants who reported a lifetime mTBI at pre-deployment for the different categories of change in PTSD symptoms (Increase, Decrease, No change) (n = 1224) between pre- and post-deployment.

Table 11.16: Percentage of participants with and without lifetime mTBI in each category of PCL-0	2
change.	

Change in PCL-C	N	Lifetime Pre- Deployment mTBI	No Lifetime Pre- Deployment mTBl
PCL-C Increase	118	30.4%	7.6%
PCL-C Decrease	21	1.8%	1.7%
PCL-C No change	1085	67.8%	90.7%

Respondents who reported a lifetime mTBI were significantly more likely to increase in PTSD symptoms between pre- and post-deployment compared to those who had no lifetime mTBI (OR = 2.16, 95% CI 1.46, 3.21).



Figure 11.5: Percentage of participants with and without lifetime mTBI for each category of PCL-C change

11.3.10 Psychological Co-Morbidity

Of the 1295 participants that completed both the pre- and post-deployment selfreport mTBI measure, 12 participants did not complete the K10, PCL-C and/or AUDIT and so were excluded from this analysis.

11.3.10.1 New post-deployment mTBI and co-morbidity

Table 11.17 shows the percentage of participants with and without a new self-reported mTBI for the different categories of psychological co-morbidity at post-deployment (n = 1283).

Co-morbidity category	N	New post-deployment mTBI
No Psychological Conditions	667	5.1%
One Psychological Condition	384	8.9%
Two Psychological Conditions	160	18.1%
Three Psychological Conditions	72	27.8%

Table 11.17: Percentage of participants in each co-morbidity category, with and without new mTBI.

There was a significant association between number of co-morbid psychological conditions and the occurrence of new mTBI at post-deployment (p<0.0001). Compared to respondents who had no psychological conditions, respondents with 2 (p<0.0001, OR = 3.25, 95% CI 1.89, 5.60) or 3 (p<0.0001, OR = 5.92, 95% CI 3.14, 11.16) were significantly more likely to have a new mTBI (Figure 11.6).





11.3.10.2 Lifetime mTBI at pre-deployment and co-morbidity

Table 11.18 (Appendix R) shows the percentage of participants with a lifetime mTBI at pre-deployment in each co-morbidity category at post-deployment. Modelling the probability of increasing co-morbidity at post-deployment for respondents with and without a lifetime mTBI at pre-deployment, while there was a significant effect of lifetime mTBI on co-morbidity (p=0.0005), the size of the effect was not large enough to be of practical significance.

11.4 Summary of Results

Table 11.19 summarises the key findings presented in this results section in relation to the questions posed in section 11.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Length of most recent deployment	Nil
Q2. Role on most recent deployment	Those respondents who were on a combat role in Afghanistan or who worked outside the main support base were significantly more likely to report a new mTBI at post-deployment, compared to those who were in non-combat roles outside Afghanistan
Q3a. Number of traumatic deployment exposures	Those respondents who had high or very high numbers of traumatic deployment exposures were significantly more likely to report a new mTBI at post-deployment compared to those who had the lowest number of exposures.

 Table 11.19: Summary of key findings presented in this chapter

Q3b. Traumatic deployment experiences	Participants who reported exposure to any of the deployment experiences were significantly more likely to report a new mTBI at post-deployment, compared to those participants who did not report these experiences
Q4. Number of prior deployments	Nil
Q5. Total time on prior deployments (Lifetime mTBI)	Nil
Q6. Previous combat exposure (Lifetime mTBI)	Those respondents who reported previous combat exposure, were more likely to report a lifetime mTBI at pre-deployment compared to those with no previous combat exposure.
Q7a. Changes in PTSD symptoms (new mTBI)	Compared to respondents whose PTSD symptoms did not change between pre- and post-deployment, respondents who had an increase in symptoms were significantly more likely to report a new mTBI at post-deployment
Q7b. Changes in PTSD symptoms (Lifetime mTBI)	Respondents who reported a lifetime mTBI were significantly more likely to increase in PTSD symptoms between pre- and post- deployment compared to those who had no lifetime mTBI
Q8a. Psychological co-morbidity at post-deployment (new mTBI)	Compared to respondents who had no psychological conditions, those with 2 or 3 were significantly more likely to have a new mTBI
Q8b. Psychological co-morbidity at post-deployment (Lifetime mTBI)	Nil

11.5 Discussion

This is first study to prospectively examine the issue of mTBI in an Australian military population. Approximately one quarter of respondents who completed the self-report mTBI questions at both pre- and post-deployment reported having incurred at least one lifetime mTBI at pre-deployment, with a further 9.3% incurring at least one new mTBI at post-deployment.

In comparison, the MEAO Census Study found that 11% reported a lifetime mTBI and 9.1% had reported a new mTBI. One important explanation for the difference in results between the two studies pertains to the definition of mTBI. While the MEAO Prospective study defined an mTBI as an injury event and immediate associated alteration of consciousness, the MEAO Census study required the respondent to have identified at least one post-concussive symptom (1). However, the use of post-concussive symptoms that may not necessarily relate to the injury and could have other causes (e.g., psychiatric diagnoses such as PTSD), introduces a major confound. For example, loss of consciousness and memory of the experience may be indicative of a dissociative reaction to a psychologically traumatic event, which is also a common occurrence during combat (17).

To date, there have been no published mTBI prevalence data for Australian military populations with most of the prevalence data coming from US populations. Among US, UK and Canadian populations, rates of mTBI in military personnel deployed to the MEAO were estimated to be between 12% and 20% (18). For example, Tanielian and Jaycox (7) reported approximately 19% of US troops deployed to the MEAO were likely to have experienced an mTBI, while Hoge et al. (2) found that approximately 15.2% of a US infantry personnel met the criteria for mTBI. Lower rates have been reported for UK and Canadian military personnel returning from deployment to Afghanistan and Iraq. Rona et al. (9) reported a rate of 4.4% across all services of UK military personnel, while Zamorski et al. (10) reported a rate of 6.4% for Canadian military personnel. One reason for the higher prevalence rate in US personnel compared to the UK may be that the US studies focused on combat exposed samples (2, 19, 20). In addition, it is possible that the way in which mTBI was defined and measured may have contributed to these differences. Finally, it is also the case that American troops deploy for longer periods of time, in comparison to their UK counterparts and therefore have great chance of exposure.

Interestingly, findings from this study suggest that many of the participants deployed having already experienced an mTBI, which was not necessarily related to prior deployment. For example, the most common injury mechanisms for participants who reported a lifetime mTBI were a vehicle accident (77.6%) and falls (72.4%). In comparison, the most common injury mechanisms for participants reporting a new mTBI were deployment related, being blast or explosion IED (69.2%) and RPG and land mine, grenade etc (62.2%). Despite these differences, the two most commonly reported symptoms to occur immediately after any of these injuries were being dazed, confused, or seeing stars and loss of consciousness/knocked out.

11.5.1 Associations with Self-Reported New and Lifetime mTBI

Associations between a number of factors and self-report mTBI were found. Factors associated with reporting a new mTBI included role on most recent deployment, the number and types of traumatic deployment experiences, increases in PTSD symptoms between pre- and post-deployment and psychological co-morbidity at post-deployment. The factors associated with reports of lifetime mTBI at pre-deployment were prior combat experience and increases in PTSD symptoms between pre- and post-deployment.

11.5.2 Role and Traumatic Deployment Experiences

Similar to other studies, respondents who were in a combat role or who operated outside of the main support base, in this study, were significantly more likely to report a new mTBI at post-deployment. In general the incidence of mTBI is higher for military personnel who have recently deployed compared to a similar non-deployed population (11). However, rather than deployment itself, mTBI is likely to be more specifically associated with combat exposure.

Prior combat exposure reported at pre-deployment was also significantly associated with not only an increased likelihood of reporting a lifetime mTBI, but also a new mTBI at post-deployment. In line with this finding, respondents who reported a high or very high number of traumatic deployment experiences on the most recent deployment were also significantly more likely to report a new mTBI at post-deployment. These findings highlight how mTBI is in part a proxy for high combat exposure with all its attendant risks. They also illustrate the need for mTBI and its associated symptoms to be carefully dissected from the impact of traumatic stress associated with combat roles independent of mTBI.

As the majority of deployment-related mTBI cases are blast-induced (9, 10, 19), it is perhaps not surprising that numerous studies have found a relationship between combat exposure and increased rates of mTBI. Rona et al. (21) found that self-reported mTBI increased from 4.4% to 9.5% when only considering the UK personnel who had performed in a combat role. Similarly, Zamorski (10) found that mTBI was more likely to be reported by those Canadian personnel with higher numbers of combat experiences. Cameron et al. (11) also reported that being exposed to combat or being in direct combat support positions increased the risk of mTBI. However, these authors did note that a large proportion of mTBI cases in the defence forces (approximately 80%) were in non-deployed personnel, suggesting that mTBIs are *not necessarily* only associated with combat exposure.

11.5.3 PTSD Symptoms

Also similar to previous research findings, in this study changes to PTSD symptoms between pre- and post-deployment were significantly associated with reporting both a lifetime mTBI at pre-deployment and a new mTBI at post-deployment. Again this relationship is complex due to the high combat exposure of the mTBI group. As combat exposure is implicated in relation to other psychological conditions, this association could arise from a range of interactions. This highlights the confounded nature of associations with mTBI and the need for caution in interpretation. The current report does not analyse a number of important relationships that deserve detailed examination.

For example, a number of previous studies have identified a significant overlap between mTBI, PTSD and persistent post-concussive symptoms. Even after removing the symptoms that overlapped such as difficulty sleeping and irritability, Schneiderman et al. (22) still found a strong association between PTSD and post-concussive symptoms. Further to this, Bogdanova and Verfaellie (23), who focused on blast related mTBI among US military personnel deployed to Iraq and Afghanistan, found significant overlap in the cognitive abnormalities from both mTBI and PTSD, in the domains of attention, executive function and memory disruptions.

A further relationship that was not analysed in this report was the role that mTBI may play in increasing the risk of developing PTSD, and/or exacerbating symptoms that are already present (24-26). Any changes to an individual's neuropsychological function as a result of mTBI may also impact on the underlying neurobiological mechanisms of PTSD (26).

11.5.4 Psychological Co-Morbidity

The findings from this study demonstrate that increased psychological co-morbidity was associated with the prevalence of a new mTBI. The complexity of this relationship has again not been explored. However, as psychological co-morbidity was also associated with higher combat exposure it is possible that the experiences related to combat moderate the relationship between psychological co-morbidity and new mTBIs.

Nevertheless a number of other potential explanations have been considered. Bryant et al. (27), examined the relationship between mTBI and psychiatric conditions in a community study of injured Australians and found that functional impairment at three months post-injury predicted psychiatric diagnoses 12 months after the initial injury. Two hypotheses were proposed to explain this finding. Firstly, the regions of the brain that regulate emotion, that are abnormal in PTSD, are also particularly at risk in blast injuries and this shared neural circuitry may explain the increased incidence of psychiatric disorders in individuals reporting an mTBI. Alternatively, the event causing the mTBI may be a proxy marker of the severity of traumatic stress experienced by the individual, leading to the development of psychological symptoms.

Relationships between psychiatric disorders and mTBI is not confined to PTSD, with studies also finding associations between mTBI and depression (28). Similar to PTSD, there is a substantial overlap in mTBI and depressive symptoms including concentration difficulties, irritability, sleep problems, headaches, fatigue and depressed mood (29). Iverson (29), for example, found that persistent post-concussive symptoms were common in a depressed civilian population. Carlson et al. (30) found that military personnel who reported a deployment-related mTBI with current symptoms, were twice as likely to be diagnosed with depression, compared to those who were currently not experiencing mTBI symptoms.

11.6 Summary

This is the first study to prospectively investigate the occurrence of mTBI in a deployed Australian military population. Approximately, 9% of the sample reported experiencing a new mTBI since the beginning of their last deployment. Not surprisingly, incurring a new mTBI on the most recent deployment was significantly associated with being in a combat role or operating outside of the main support base, and reporting more than 16 traumatic deployment exposures on the most recent deployment. Similar to other studies, having already incurred an mTBI prior to the most recent deployment, and incurring a new mTBI on the most recent deployment were significantly associated with increased PTSD symptoms between pre- and post-deployment, and meeting the criteria for at least moderate risk in two or three comorbid psychological conditions at post-deployment.

The next chapter in this section focuses on **cardiovascular health** (Chapter Twelve). Once again, after providing a short introduction, the primary results are presented and discussed. Other chapters in this section then focus on:

- Respiratory health, chapter thirteen
- Skin conditions, chapter fourteen
- Infectious Diseases in Chapter Fifteen
- **Biochemistry** in Chapter Sixteen

Further sections within this report focus on:

- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- Conclusions and Limitations are presented in Chapter Twenty Two

11.7 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

- Is there an interaction between the various deployment-related factors, age and prior exposures, on depressive symptoms?
- What factors are associated with different trajectories of depressive symptoms (decreasing, stable and increasing symptoms)?

- What is the impact of the pre-deployment symptom interpretation questionnaire, on the pattern of depression symptom reporting?
- Is there a hierarchy of depressive symptoms that emerges in the postdeployment environment?
- Is there an association between PTSD, depression and post-concussive symptoms?
- Is there an association between measures of inflammatory mediators in the presence of PTSD and post-concussive symptoms?
- Are neurocognitive changes associated with mTBIs that exist in those with and without psychological symptoms?
- Is there an association between Herpes Virus and Cytomegalovirus and any neurocognitive changes in participants' reporting an mTBI?

11.9 References

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Chapter Twelve – Cardiovascular Health

Key Points

- 1. The **majority of participants fell within a normal range** for most of the cardiovascular risk categories at post-deployment:
 - 85.1% met the criteria for normal waist to hip ratios.
 - 82.2% met the criteria for normal blood pressure risk categories
 - 84.5% met the criteria for average to excellent cardiovascular fitness as measured by the Queens College Step Test.
- 2. Small changes were found for some of the cardiovascular health indicators between pre- and post-deployment, and these were significantly associated with several factors related to the **most recent deployment**.
- 3. Specifically, these **significant associations** were between:
 - a longer deployment period, and increases in Body Mass Index (BMI), increases in blood pressure and decreases in cardiovascular fitness.
 - being in a combat role or operating outside of the main support base and decreases in cardiovascular fitness,
 - reporting a number of different traumatic deployment experiences and both increases in BMI and decreases in cardiovascular fitness; and
 - reporting more than five different deployment exposures and decreases in cardiovascular fitness.
- 4. No significant associations were found between changes in cardiovascular indicators between pre- and post-deployment, and factors associated with prior deployments.

This chapter presents and discusses the findings relating to changes to cardiovascular health between pre- and post-deployment. The chapter begins by briefly discussing current literature pertaining to cardiovascular health. Primary results are then provided including waist to hip ratio, body mass index (BMI), blood pressure and cardiovascular fitness as measured by the Queens College Step Test. A comparison of scores between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure, is provided. All subsequent analyses within the result sections include only those participants who completed both the pre- and post-deployment measures. The chapter concludes by discussing the primary findings pertaining to changes in cardiovascular health.

12.1 Introduction

Three key indicators have been used to predict cardiovascular health in general and military populations - proxy measures of obesity including waist-to-hip ratio and BMI (1); measures of hypertension such as systolic and diastolic blood pressure; and lastly, cardio-respiratory fitness.

There has been considerable debate as to which is the most effective proxy measure of obesity. As BMI does not take into account the composition (2) or distribution (3) of body weight, it may not be the most accurate proxy for obesity. In fit populations with increased muscle mass, a better indicator may be waist to hip ratio which measures weight stored in the abdominal area (3). Other studies have found, however, that both BMI and waist to hip ratio are equally effective proxies for obesity (4).

Approximately 63% of Australians are either overweight or obese (5), which is far lower than the rates of obesity in other Western countries such as America (6). Interestingly, rates of obesity in the ADF have been found in the past to be somewhat higher than the general population in Australia. For example, Sim et al (7) found that more than 75% of Australian Gulf War 1990-91 veterans were either overweight or obese according to their BMI.

In contrast, the prevalence of hypertension in the military may be less than found in general populations. For example, the prevalence of hypertension in the general Australian population has been estimated to be approximately 30% for males and 20% for females (8). In comparison, Sim et al. (7) found that just under 20% of male Australian Gulf War veterans (Mean age = 38 years) had high blood pressure. Importantly, high levels of physical fitness can reduce mortality risk in people with hypertension (9), and may therefore be a better predictor of cardiovascular health outcomes than the proxy measures of obesity discussed above (10).

Modifiable risk factors for cardiovascular health include being overweight or obese, smoking, and excessive alcohol consumption (11). There is also mixed evidence regarding the specific impact of deployment on weight, blood pressure and fitness. Sim et al. (2003) found no significant differences between deployed and non-deployed Australian Gulf War veterans on measures of BMI, blood pressure or fitness in a follow up study conducted 10 years after deployment. However, other studies have shown weight to increase and fitness to decrease between pre- and post-deployment (12).

There is stronger evidence to suggest that exposure to combat stress is associated with, and may even be causally implicated in, the development of hypertension. In military populations, combat exposure has been found to be associated with both transient increases in blood pressure (13), as well as diagnosed hypertension (14, 15). Combat exposure may also influence hypertension indirectly through mental disorders, with research showing higher rates of hypertension among veterans with post traumatic stress disorder (16) and panic disorder (17).

12.2 Measures

The following objective indices (Table 12.1) were collected at both pre- and postdeployment as indicators of cardiovascular health (see Appendix D).

Table 12.1 Objective indices relating to cardiovascular health

Waist to Hip Ratio – The normal range for:

- Australian males is < 0.9; and for
- Australia females is < 0.8.

Individuals with a waist to hip ratio above these scores are considered to be obese (18).

Body Mass Index - BMI was defined as the weight in kilograms divided by the square of the height in meters (kg/m²).

- Underweight is considered to be < 18.5,
- Normal 18.5 <25.0,
- Pre-obese 25.0 <30.0,
- Obese Class 1 30.0-<35.0,
- Obese Class 2 35.0-<40.0; and
- Obese Class 3 >=40.0 (19).

Blood Pressure – Measurements account for both systolic and diastolic blood pressure:

- optimal systolic <120 and diastolic <80,
- normal systolic <130 and diastolic <85,
- high-normal systolic between 130 and 139 and diastolic between 85 and 89,
- mild hypertension systolic between 140 and 159 and diastolic between 90 and 99
- moderate hypertension systolic between 160 and 179 and diastolic between 100 and 109
- severe hypertension systolic \geq 180 and diastolic \geq 110
- isolated systolic hypertension systolic ≥140 and diastolic <90 (20)

Cardio-respiratory fitness - Is measured by heart rate recovery in the Queens College Step Test (21). The following published categories have been established for males:

- <121 is considered excellent
- 121 148 is considered above average
- 149 156 is considered average
- 162 157 is considered below average
- >162 is considered poor

The following published categories have been established for females:

- <129 is considered excellent
- \circ 129 158 is considered above average
- \circ 159 166 is considered average
- \circ 167 170 is considered below average
- \circ >170 is considered poor

12.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between the different cardiovascular indices?
- 2. Is there an association between **length of most recent deployment** and changes in cardiovascular indices between pre- and post-deployment?
- 3. Is there an association between **role on most recent deployment** and changes in cardiovascular indices between pre- and post-deployment?
- 4. Is there an association between **traumatic deployment experiences** while on most recent deployment, and changes in cardiovascular indices between pre- and post-deployment?
- 5. Is there an association between a **change in tobacco usage** and changes in cardiovascular indices between pre- and post-deployment?
- 6. Is there an association between the **psychological co-morbid groups** and changes in cardiovascular indices between pre- and post-deployment?

12.2.2 Sample Sizes

As noted above (Section 12.2), four objective indices were used to measure cardiovascular health – namely waist to hip ratio, BMI, systolic and diastolic blood pressure and the Queens College Step Test. While all were measured as part of the physical test, a small number of respondents did not take part in each component, primarily because of injury and/or they chose not to. Therefore, there are variations in the sample sizes between different analyses in the results.

There may also be some variation to the sample sizes used for specific analyses due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

12.2.2.1 Waist to Hip Ratio

The total sample size used **to identify change in waist to hip ratio between preand post-deployment** was 390. Of the 399 participants who completed both a preand post-deployment physical test, seven participant did not complete these measures at pre-deployment and two participants did not complete the measure at post-deployment.

The total sample size used **to compare pre-deployment waist to hip** for only predeployment participants, with pre- and post-deployment physical testing participants was 256.

12.2.2.2 BMI

The total sample size used to identify change in BMI between pre- and postdeployment was 399.

The total sample size used **to compare pre-deployment BMI** for only predeployment participants, with pre- and post-deployment physical testing participants was 256.

12.2.2.3 Systolic and Diastolic Blood Pressure

The total sample size used **to identify change in blood pressure** between pre- and post-deployment was 396. Of the 399 participants who completed both a pre- and a post-deployment physical test, three participants were excluded - three participants did not complete it at post-deployment.

The total sample size used **to compare pre-deployment blood pressure** for only physical testing participants, with pre- and post-deployment physical testing participants was 256.

12.2.2.4 Cardiovascular Fitness

The total sample size used **to identify change in outcomes for cardiovascular fitness** as measured by the Queens College Step Test between pre- and postdeployment was 348. Of the 399 participants who completed both a pre- and a postdeployment physical test, 51 were excluded - 15 participants did not complete the test at pre-deployment, 33 did not complete the test at post-deployment and three respondents did not complete the test at either pre- or post-deployment.

The total sample size used **to compare pre-deployment** outcomes for cardiovascular fitness as measured by the Queens College Step Test, for pre-deployment only physical testing participants, with pre- and post-deployment physical testing participants, was 244. Of the 256 participants who only completed a physical test at pre-deployment, 12 participants did not participate in the Queens College Step Test.

12.2.3 Data Analysis

For waist-to-hip ratio, body mass index and the Queens College Step Test, a mixed model for repeated measures was used to analyse these continuous outcomes. This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post-deployment) and their interaction(s) are included as fixed effects in the model.

Blood pressure was categorised into seven bands (optimal, normal, high-normal, mild hypertension, moderate hypertension, severe hypertension and isolated systolic hypertension) at pre-deployment and post-deployment. Stepwise change across bands (1 step, 2 step, 3 step, 4 step, etc) between pre- and post-deployment was then calculated for each participant. For the purposes of modelling, these changes were then simplified into three change categories ('Increase', 'Decrease' or 'No change').

The change categories were then used as a three level categorical outcome in a multinomial logit model. This approach allowed for the shift in severity of symptoms between the two time points to be examined. In all models the default reference category was 'no change'. Where a different reference category was used, this is stated in the text.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences.

12.3 Results for Cardiovascular Health

The following information relates to a descriptive analysis for each of the cardiovascular health indices measured in the MEAO Prospective Study.

12.3.1 Waist to Hip Ratio

The group who only completed pre-deployment measures was compared with those who completed both the pre- and post-deployment physical test (see Table 12.2, Appendix S), and no differences were identified.

For respondents who completed both pre- and post-deployment physical testing, the mean waist to hip ratios were 0.85 and 0.85 respectively (difference = 0.0, CI 0.01, 0.00), and this change was not statistically significant (p=0.49) (see Table 12.3, Appendix S).

Table 12.4 summarises the results for waist to hip ratio risk categories at pre- and post-deployment for responders who completed both the pre- and post-deployment physical test.

Hip to Waist Ratio		Po	Total	
		Normal N(%)	Obesity N(%)	
Pre	Normal	315 (80.7%)	32 (8.2%)	347
	Obesity	17 (4.4%)	26 (6.7%)	43
Total		332	58	390

Table 12.4: Summary of changes to waist to hip ratio between pre- and post-deployment.

While 87.4% of responders did not change risk categories between pre- and postdeployment, an additional 8.2% of respondents were considered to be obese at postdeployment (Table 12.5 Appendix S).

12.3.2 BMI

The BMIs of those participants who only completed the pre-deployment measures relating to BMI were no different to those who completed both pre- and post-deployment BMI measures (p=0.33) (see Table 12.6, Appendix S).

For respondents who completed both pre- and post-deployment physical testing, the mean BMIs were 26.0 and 26.6 respectively (difference = 0.6, CI 0.4, 0.7), and this increase was statistically significant (p<0.0001) (see Table 12.7, Appendix S).

Table 12.8 summarises the risk categories at pre- to post-deployment for respondents who completed both the pre- and the post-deployment physical testing.

 Table 12.8: Summary of BMI risk categories at pre- and post-deployment for pre- and post-deployment responders.

	BMI		Total		
		Normal N(%)	Pre-obese N(%)	Obese N(%)	
Pre	Normal	108 (27.1%)	50 (12.5%)	0 (0.0%)	158
	Pre-Obese	8 (2.0%)	181 (45.3%)	16 (4.0%)	205
	Obese	1 (0.3%)	7 (1.8%)	28 (7.0%)	36
Total		117	238	44	399

While 79.4% of responders did not change risk categories between pre- and postdeployment for BMI, an additional 16.5% of respondents increased from normal to either pre-obese (12.5%), or pre-obese to obese (4.0%) (Table 12, Appendix S).

12.3.3 Systolic and Diastolic Blood Pressure

There were no significant differences in pre-deployment mean systolic (p=0.24) or diastolic (p=0.94) blood pressures between respondents who only completed a pre-deployment physical test, in comparison to those who completed both a pre- and post-deployment physical test (see Tables 12.10 and Table 12.11, Appendix S).

For respondents who completed both pre- and post-deployment physical testing, mean systolic blood pressures were 121.5 and 121.0 respectively (difference = -0.5, Cl -1.5, 0.4) and this change was not statistically significant (p=0.28) (see Table 12.12, Appendix S). The mean diastolic blood pressures at pre- and post-deployment were 66.5 and 68.1 respectively (difference = 1.6, Cl 0.8, 2.4), and this increase was significant (p=0.0001) (see Table 12.13, Appendix S).

Table 12.14 summarises the risk categories at pre- and post-deployment for respondents who completed both the pre- and the post-deployment physical testing.

Bl	ood Pressure	Post					Total
		Optimal N(%)	Normal N(%)	High Normal N(%)	Hypertension N(%)	Isolated Systolic Hypertension N(%)	
Pre	Optimal	126 (31.8%)	49 (12.3%)	5 (1.3%)	0 (0.0%)	0 (0.0%)	180
	Normal	44 (11.1%)	62 (15.6%)	22 (5.5%)	3 (0.8%)	3 (0.8%)	134
	High Normal	5 (1.3%)	29 (7.3%)	17 (4.3%)	1 (0.3%)	4 (1.0%)	56
	Hypertension	1 (0.3%)	0 (0.0%)	1 (0.3%)	2 (0.5%)	0 (0.0%)	4
	Isolated Systolic Hypertension	4 (1.0%)	6 (1.5%)	6 (1.5%)	2 (0.5%)	4 (1.0%)	22
Tota	I	180	146	51	8	11	396

 Table 12.14: Summary of blood pressure risk categories at pre- and post-deployment for pre- and post-deployment responders.

The majority of respondents (53.2%) did not change risk categories between preand post-deployment (Table 12.15, Appendix S).

12.3.4 Cardiovascular Fitness

Mean pre-deployment scores for the Queens College Step Test were not significantly different (p=0.82) for respondents who only completed a pre-deployment physical test, compared to those who completed both a pre- and post-deployment physical test (see Table 12.16, Appendix S).

For respondents who completed both pre- and post-deployment physical testing, the mean scores for the Queens College Step Test were 124.9 and 142.1 respectively (difference = 17.2 Cl 15.5, 18.9) and this increase was statistically significant (p<0.0001) (Table 12.17, Appendix S).

Table 12.18 summarises the risk categories at pre- and post-deployment for respondents who completed both the pre- and post-deployment physical testing.

St	ep Test	Post				Total	
		Excellent N(%)	Above Average N(%)	Average N(%)	Below Average N(%)	Poor N(%)	
Pre	Excellent	16 (4.6%)	105 (30.1%)	10 (2.9%)	4 (1.2%)	2 (0.6%)	137
	Above Average	5 (1.4%)	106 (30.4%)	37 (10.6%)	19 (5.4%)	21 (6.0%)	188
	Average	0 (0.0%)	4 (1.2%)	5 (1.4%)	2 (0.6%)	4 (1.2%)	15
	Below Average	1 (0.3%)	0 (0.0%)	2 (0.6%)	0 (0.0%)	2 (0.6%)	5
	Poor	0 (0.0%)	0 (0.0%)	3 (0.9%)	0 (0.0%)	0 (0.0%)	3
Total		22	215	57	25	29	348

 Table 12.18: Summary of cardiovascular fitness risk categories at pre- and post-deployment for preand post-deployment responders.

The majority of respondents (59.2%) moved into a higher risk category between preand post-deployment. A further 4.4% of respondents decreased risk category, while 36.4% stayed the same (Table 12.19, Appendix S).

12.3.5 Association Between Cardiovascular Indices

This section begins by looking at the correlations between pre- post-deployment change in WHR, BMI, Systolic and Diastolic BP and Step test. Correlations showing the association between each of the cardiovascular indices are shown in Table12.20.

	WHR Change	BMI Change	BP Systolic Change	BP Diastolic Change	Step test Change
WHR					
Change	1	0.10*	-0.06	0.09	-0.09
BMI Change					
	0.10*	1	0.26*	0.15*	0.20*
BP Systolic					
Change	-0.06	0.26*	1	0.46*	0.14*
BP Diastolic					
Change	0.09	0.15*	0.46*	1	0.12*
Step test					
Change	-0.09	0.20*	0.14*	0.12*	1

Table 12.20: Correlations between waist to hip ratio, BMI, blood pressure, and step test.* denotes p<=0.05

It can be seen that systolic and diastolic blood pressures share the strongest association. Furthermore, their associations with other indices are similar in magnitude and direction. For this reason, for the remainder of this section, systolic and diastolic blood pressures have been examined together as 'blood pressure'. It can also be seen that blood pressure change is associated with change in BMI and change in cardiovascular fitness as measured by the Queens College Step Test between pre- and post-deployment (Figure 12.1).



Figure 12.1: Associations between cardiovascular health indices

12.3.6 Length of Most Recent Deployment

12.3.6.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratio between pre- and post-deployment, for each 'Length of recent deployment' category (n = 390) are presented in Table 12.21 (Appendix S). As can be seen from this table, length of most recent deployment was not significantly associated with changes to waist-to-hip ratio between pre- and post-deployment.

12.3.6.2 BMI

The mean changes to BMI between pre- and post-deployment, for each 'Length of recent deployment' category (n = 399) are presented in Table 12.22.

Length of current deployment (months)	N	Pre-deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% CI)
≤5 months	97	26.91	26.80	-0.11
		(26.36, 27.46)	(26.26, 27.34)	(-0.36, 0.13)
6 or 7 months	161	26.04	26.79	0.75
		(25.61, 26.47)	(26.37, 27.21)	(0.56, 0.94)
8 months	98	25.64	26.31	0.67
		(25.09, 26.18)	(25.77, 26.85)	(0.43, 0.92)
9-12 months	43	25.04	25.98	0.94
		(24.21, 25.86)	(25.17, 26.79)	(0.57, 1.31)

Table 12.22: Mean (95% CI) change in BMI for length of recent deployment.

As can be seen from Table 12.22, while the overall changes to BMI between pre- and post-deployment were small, for those who were away on deployment for \leq 5 months this change was statistically significantly less, on average, than the change in BMI for those away for 6 or 7 months (p<0.0001), 8 months (p<0.0001) and 9-12 months (p<0.0001) (Figure 12.2).



Figure 12.2: Mean BMI scores at each deployment time for each length of recent deployment category

12.3.6.3 Blood pressure

Table 12.23 shows the percentage of participants in each blood pressure change category (Increase, Decrease, No change), for the different 'Length of recent deployment' categories (n = 396).

Length of Recent	N	BP	BP	BP
Deployment		Increase	Decrease	No change
≤ 5 Months	97	19.6%	35.0%	45.4%
6-7 Months	159	23.9%	16.3%	59.8%
8 Months	98	27.6%	18.4%	54.1%
9-12 Months	42	7.1%	47.6%	45.2%

 Table 12.23: Percentage of participants in each blood pressure change category for each length of recent deployment

Using ' \leq 5 Months' as the predictor reference, and 'No change' as the outcome reference, there was a significant association between length of recent deployment and change in blood pressure (p=0.0002). Compared to those respondents who had been deployed for less than or equal to 5 months, those who had been deployed for 6 to 7 months were significantly less likely to have a decrease in blood pressure (p=0.002, OR = 0.35, 95% CI 0.19, 0.66). Similarly those who had deployed for 8 months were less likely to have a decrease in blood pressure (p= 0.06, OR = 0.44, 95% CI 0.22, 0.88). In comparison, those who were deployed for 9-12 months were more likely to have a decrease in blood pressure, compared to no change (p=0.008, OR=1.36, 95% CI 0.63, 2.95). This association is illustrated below in Figure 12.3.





12.3.6.4 Cardiovascular Fitness

The mean changes to step test scores between pre- and post-deployment for each 'Length of recent deployment' category (n = 348) are presented in Table 12.24.
Length of current deployment (months)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% Cl)
≤5 months	85	120.84	134.51	13.67
		(117.33, 124.34)	(131.50, 137.51)	(10.36, 19.98)
6 or 7 months	136	126.92	145.00	18.08
		(124.15, 129.69)	(142.62, 147.38)	(15.46, 20.70)
8 months	89	126.33	142.62	16.29
		(122.90, 129.75)	(139.68, 145.56)	(13.06, 19.53)
9-12 months	38	123.58	147.58	24.00
		(118.34, 128.82)	(143.08, 152.08)	(19.05, 28.95)

Table 12.24: Mean (95% CI) change in step test score for length of recent deployment.

As can be seen from Table 12.24, the increase in step test scores between pre- and post-deployment was significantly greater, on average, for those deployed for 9-12 months, compared to those away for \leq 5 months (p=0.0007), 6 or 7 months (p=0.04), and 8 months (p=0.01) (Figure 12.4).



Figure 12.4: Mean step test scores for each deployment time for each length of recent deployment category

12.3.7 Role on Most Recent Deployment

12.3.7.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratio between pre- and post-deployment for the different 'Role on recent deployment' categories (n = 327) are presented in Table 12.25 (Appendix S). As can be seen in this table, the change in waist-to-hip ratio from pre- and post-deployment was not significantly different between those whose role was Combat Afghan or Outside MSB, Inside MSB, or Outside Afghan.

12.3.7.2 BMI

The mean changes to BMI between pre- and post-deployment for the different 'Role on recent deployment' categories (n = 335) are presented in Table 12.26 (Appendix S). As can be seen in this table, while BMI did increase between pre- and post-deployment, there were no significant differences in this change between the different role groups.

12.3.7.3 Blood pressure

Table 12.27 (Appendix S) shows the percentage of respondents with each category of change in blood pressure between pre- and post-deployment (Increase, Decrease, No change), for the different 'Role on recent deployment' categories (n = 332). Using 'Outside Afghan' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between role on most recent deployment and BP category change.

12.3.7.4 Cardiovascular fitness

The mean changes to step test scores between pre- and post-deployment, for the different 'Role on recent deployment' categories (n = 300) are presented in Table 12.28.

Role on recent	N	Pre-deployment	Post-deployment	Change
deployment		(95% CI)	(95% CI)	(95% CI)
Combat Afghan &	247	123.84	142.36	18.51
Outside MSB		(121.85 125.83)	(140.55, 144.16)	(16.72, 20.31)
Inside MSB	37	128.16	145.70	17.54
		(123.02, 133.30)	(141.04, 150.36)	(12.91, 22.17)
Outside Afghan	16	141.00	140.19	-0.81
		(133.19, 148.81)	(133.10, 147.28)	(-7.85, 6.23)

Table 12.28: Mean (95% CI) change in step test score for each role on deployment.

As can be seen in Table 12.28, the change in step test scores between pre- and post-deployment, was significantly greater, on average, for those whose role was Combat Afghan or Outside MSB (p<0.0001) and those whose role was Inside MSB (p<0.0001), compared to those Outside Afghan (Figure 12.5).



Figure 12.5: Mean step test scores at each deployment time for each role on most recent deployment.

12.3.8 Number of Traumatic Deployment Exposures

12.3.8.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratio between pre- and post-deployment for each number of deployment exposures (n = 316) are presented in Table 12.29 (Appendix S). As can be seen from this table, waist-to-hip ratio did not change significantly between pre- and post-deployment, regardless of the number of deployment exposures.

12.3.8.2 BMI

The mean changes to BMI between pre- and post-deployment for each number of traumatic deployment exposures (n = 324) are presented in Table 12.30 (Appendix S). There were no significant differences in the increase in BMI from pre- to post-deployment between the different numbers of deployment exposures.

12.3.8.3 Blood pressure

The proportion of participants with increases, decreases or no change in blood pressure between pre- and post-deployment, for each number of deployment exposures (n = 321) are presented in Table 12.31 (Appendix S). Using 'Low exposures' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between number of deployment exposures and BP change.

12.3.8.4 Cardiovascular Fitness

The mean changes to step test scores between pre- and post-deployment for each number of deployment exposures (n = 291) are presented in Table 12.32.

Deployment exposure (category)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
Low	17	133.76	139.53	5.76
		(126.12, 141.41)	(132.76, 146.30)	(-1.33, 12.86)
Medium	37	132.92	149.22	17.30
		(126.74, 137.10)	(144.63, 153.81)	(12.49, 22.10)
High	91	126.71	144.79	18.08
		(123.41, 130.02)	(141.86, 147.72)	(15.01, 21.14)
Very High	146	121.94 (119.33, 124.55)	140.11 (137.80, 142.42)	18.17 (15.75, 20.59)

Table 12.32: Mean (95% CI) change in step test scores for different numbers of deployment exposures.

As can be seen in Table 12.32, the change in step tests scores between pre- and post-deployment was significantly different between the numbers of deployment exposures (p=0.01). Compared to those with the lowest number, those with medium (p=0.008), high (p=0.002) and very high (p=0.001) numbers of deployment exposures all had a greater increase in their step test score (Figure 12.6).



Figure 12.6: Mean step test scores at each deployment time for each category of number of traumatic exposures.

12.3.9 Traumatic Deployment Experiences

In the analysis of associations between cardiovascular health indices and reported categories of traumatic experiences on most recent deployment, note that each respondent could have responded positively to more than one experience. Coming under fire, exposure to vulnerable situations or fear of events and casualties among those close to you were the most common deployment experiences reported by respondents. Being in danger of being killed, and seeing/handling dead bodies were also reported by three quarters of these respondents- a finding in contrast to previous chapters.

12.3.9.1 Waist-to-hip ratio

The percentage of respondents who had indicated at least one exposure to each of the nine categories of deployment experience is summarised in Table 12.33 (Appendix S), along with associated change in waist-to-hip ratio between pre- and post-deployment (n = 316). There were no significant associations between any of the deployment exposures and change in waist-to-hip ratio between pre- and post-deployment.

12.3.9.2 BMI

The percentage of respondents who had indicated at least one exposure to each of the nine categories of deployment experience is summarised in Table 12.34, along with associated change in BMI between pre- and post-deployment (n = 324).

Deployment	Exj	posed	Unexposed		
Experiences	Number	Change BMI	Number	Change BMI	
	(%)	(95% CI)	(%)	(95% CI)	
Coming under fire	30	0.55	293	0.31	
	(90.7%)	(0.41, 0.70)	(9.3%)	(-0.15, 0.76)	
Vulnerable situations or fear of events	302 (93.2%)	0.53 (0.39, 0.68)	22 (6.8%)	0.30 (-0.23, 0.84)	
Casualties among those close to you	276	0.57	47	0.25	
	(85.5%)	(0.42, 0.72)	(14.5%)	(-0.12, 0.61)	
Seeing/handling dead	238	0.55	85	0.43	
bodies	(73.7%)	(0.39, 0.71)	(26.3%)	(0.16, 0.70)	
In danger of being	254	0.58	69	0.31	
killed/injured	(78.6%)	(0.42, 0.74)	(21.4%)	(0.00, 0.61)	
Discharging own	179	0.59	144	0.45	
weapon	(55.4%)	(0.40, 0.77)	(44.6%)	(0.25 <i>,</i> 0.66)	
Unable to respond to a threatening situation	119 (37.0%)	0.52 (0.29, 0.75)	203 (63.0%)	0.51 (0.33, 0.69)	
Human degradation	80	0.79	243	0.43	
	(24.8%)	(0.51, 1.06)	(75.2%)	(0.27, 0.59)	
Actions resulting in	47	0.70	276	0.49	
injury or death	(14.6%)	(0.33, 1.06)	(85.4%)	(0.34, 0.64)	

 Table 12.34: Mean (95% CI) BMI change for traumatic deployment experiences.

Apart from human degradation, there were no other significant associations between any of the deployment experiences and change in BMI between pre- and postdeployment. Respondents who were exposed to human degradation had a significantly greater increase in BMI compared to those who were no exposed (p=0.03).

12.3.9.3 Blood pressure

The percentage of respondents in each BP change category who had indicated at least one exposure to each of the nine categories of deployment experience (n = 321) is summarised in Table 12.35 (Appendix S). Using 'No change' as the outcome

reference, there were no significant associations between any of the deployment exposures and change in blood pressure between pre- and post-deployment.

12.3.9.4 Cardiovascular Fitness

The percentage of respondents who had indicated at least one exposure to each of the nine categories of deployment experience is summarised in Table 12.36, along with associated change in step test scores between pre- and post-deployment (n = 291).

Deployment	E	xposed	Un	exposed
Experiences	Number (%)	Change Step Test Scores (95% CI)	Number (%)	Change Step Test Scores (95% Cl)
Coming under fire	262 (90.3%)	18.01 (16.19, 19.83)	28 (9.7%)	10.75 (5.19, 16.31)
Vulnerable situations	271	18.40	20 (6.9%)	6.00
or fear of events	(93.1%)	(16.37, 19.91)		(-0.50, 12.50)
Casualties among those close to you	246	18.26	44	11.43
	(84.8%)	(16.40, 20.13)	(15.2%)	(7.03, 15.84)
Seeing/handling dead	214	17.87	76	15.4
bodies	(73.8%)	(15.85, 19.89)	(26.2%)	(12.03, 18.81)
In danger of being killed/injured	225	18.19	65	13.91
	(77.6%)	(16.22, 20.15)	(22.4%)	(10.26, 17.56)
Discharging own	160	19.05	130	15.17
weapon	(55.2%)	(16.72, 21.38)	(44.8%)	(12.58, 17.76)
Unable to respond to a threatening situation	105 (36.3%)	18.61 (15.72, 21.49)	184 (63.7%)	16.48 (14.30, 18.67)
Human degradation	71 (24.5%)	19.18 (15.68, 22.69)	219 (75.5%)	16.59 (14.60, 18.59)
Actions resulting in	42	19.62	248	16.82
injury or death	(14.5%)	(15.06, 24.18)	(85.5%)	(14.95, 18.70)

Table 12.36: Mean (95% CI) step test score change for traumatic deployment experiences.

For those exposed to vulnerable situations or fear of events (p=0.0005), coming under fire (p=0.02), discharging own weapon (p=0.03), being in danger of being killed or injured (p=0.04), and having casualties among those close to them (p=0.005), the change in step test scores between pre- and post-deployment was significantly greater compared to those who were not exposed to that experience.

12.3.10 Alcohol Usage

12.3.10.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratio between pre- and post-deployment for each AUDIT change category (Increase, Decrease, No change) (n = 290) are presented in Table 12.37 (Appendix S). As can be seen in this table, there were no significant differences in the change in waist-to-hip ratio between the different AUDIT change categories.

12.3.10.2 BMI

The mean changes to BMI between pre- and post-deployment for each AUDIT change category (Increase, Decrease, No change) (n = 297) are presented in Table 12.38 (Appendix S). As can be seen from this table, the increase in BMI did not differ significantly between the AUDIT change categories.

12.3.10.3 Blood Pressure

Table 12.39 (Appendix S) shows the percentage of respondents in each category of change in blood pressure between pre- and post-deployment (Increase, Decrease, No change), for each AUDIT change category (Increase, Decrease, No change) (n = 294). Using 'AUDIT no change' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between AUDIT change category and blood pressure change.

12.3.10.4 Cardiovascular Fitness

The mean changes to step test scores between pre- and post-deployment for each AUDIT change category (Increase, Decrease, No change) (n = 265) are presented in Table 12.40 (Appendix S). As can be seen from this table, the overall increase in step test scores between pre- and post-deployment was not significantly different between AUDIT change categories.

12.3.11 Smoking Status

12.3.11.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratios between pre- and post-deployment for the different 'Smoking status' categories (n = 251) are presented in Table 12.41, (Appendix S). As can be seen from this table, waist-to-hip ratio did not change significantly between pre- and post-deployment, for any of the smoking status categories.

12.3.11.2 BMI

The mean changes to BMI between pre- and post-deployment for the different 'Smoking status' categories (n = 255) are presented in Table 12.42 (Appendix S). As can be seen from this table, the difference between the smoking status categories in the increase in BMI was only marginally significant.

12.3.11.3 Blood Pressure

Table 12.43 (Appendix S) shows the percentage of participants in each blood pressure change category (Increase, Decrease, No change), for the different 'Smoking status' categories (n = 252). Using 'Smoked pre- only' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between smoking status and change in blood pressure.

12.3.11.4 Cardiovascular Fitness

The mean changes to step test scores between pre- and post-deployment for the different 'Smoking status' categories (n = 221) are presented in Table 12.44 (Appendix S). As can be seen from this table, the difference in step test score change between the smoking status categories was not significant.

12.3.12 Smoking Behaviour

Due to the small sample size in some categories for this item, 'smoked the same amount' and 'smoked less than usual' were grouped together for the purposes of the following analyses.

12.3.12.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratio between pre- and post-deployment for the different 'Smoking behaviour' categories (n = 145) are presented in Table 12.45

(Appendix S). As can be seen from this table, waist-to-hip ratio did not change significantly between pre- and post-deployment, for any of the smoking behaviour categories.

12.3.12.2 BMI

The mean changes to BMI between pre- and post-deployment for the different 'Smoking behaviour' categories (n = 149) are presented in Table 46 (Appendix S). As can be seen from this table, the overall increase in BMI did not differ significantly between the smoking behaviour categories.

12.3.12.3 Blood Pressure

Table 12.47 (Appendix S) shows the percentage of participants in each blood pressure change category (Increase, Decrease, No change), for the different 'Smoking behaviour' categories (n = 146). Using 'Smoked more than usual' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between smoking behaviour and change in blood pressure.

12.3.12.4 Cardiovascular Fitness

The mean changes to step test scores between pre- and post-deployment for the different 'Smoking behaviour' categories (n = 133) are presented in Table 12.48 (Appendix S). As can be seen from Table 12.48, the difference between smoking behaviour categories, in the change in step test scores, was only marginally significant.

12.3.13 Psychological Co-Morbidity

12.3.13.1 Waist-to-hip ratio

The mean changes to waist-to-hip ratios between pre- and post-deployment for the different co-morbidity categories (n = 325) are presented in Table 12.49 (Appendix S). As can be seen from this table, waist-to-hip ratio did not change significantly between pre- and post-deployment, for any of the co-morbid categories.

12.3.13.2 BMI

The mean changes in BMI between pre- and post-deployment for the different comorbidity categories (n = 333) are presented in Table 12.50 (Appendix S). As can be seen from this table, there was no significant difference in the increase in BMI between the co-morbid categories.

12.3.13.3 Blood Pressure

Table 12.51 (Appendix S) shows the percentage of participants in each blood pressure change category (Increase, Decrease, No change), for the different comorbidity categories (n = 330). Using 'None' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between number of co-morbid psychological conditions and change in blood pressure.

12.3.13.4 Cardiovascular Fitness

The mean changes to step test scores between pre- and post-deployment for the different co-morbidity categories (n = 298) are presented in Table 12.52 (Appendix S). As can be seen from this table, the increase in step test scores was not significantly different between the co-morbid categories.

12.4 Summary of Results

Table 12.53 summarises the key findings presented in this results section in relation to the questions posed in Section 12.2.1 of this chapter. A discussion section which

draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Associations between different cardiovascular indices	There was evidence of a strong association between systolic and diastolic blood pressures, and their associations with other indices were similar in magnitude and direction. Change in blood pressure between pre- and post-deployment was associated with change in BMI and change in cardiovascular fitness as measured by the Queens College Step Test.
Q3. Length of most recent deployment	Compared to participants who were away for <= 5months, those away for 6 or 7 months, 8 months, or 9-12 months had a significantly greater increase in BMI between pre- and post- deployment.
	Compared to participants who were away for <= 5months, a smaller proportion of those away for 6 to 7 months recorded a decrease in blood pressure.
	The increase in step test scores between pre- and post-deployment was significantly greater for those deployed for 9-12 months, compared to those away for <= 5 months, 6 or 7 months, and 8 months.
Q4. Role on most recent deployment	The change in step test results between pre- and post-deployment, was significantly greater for those whose role was Combat Afghan or Outside MSB, and those whose role was Inside MSB, compared to those Outside Afghan.
Q5a. Number of traumatic deployment exposures	Compared to those with the lowest number, those with medium, high and very high numbers of deployment exposures all had a greater increase in their step test score between pre- and post- deployment.
Q5b. Traumatic deployment experiences	Respondents who were exposed to human degradation had a significantly greater increase in BMI compared to those who were not exposed.
	Respondents exposed to vulnerable situations or fear of events, coming under fire, discharging own weapon, being in danger of being killed or injured, and having casualties among those close to them, had a significantly greater change in step test results between pre- and post-deployment compared to those who were not exposed.
Q6. Changes in alcohol use	Nil

Table 12.53: Summary of key findings presented in this chapter

Q7a. Changes in smoking status	Nil
Q7b. Changes in smoking behaviour	Nil
Q2. Co-morbidity at post-deployment	Nil

12.5 Discussion

As was anticipated for a group deemed fit for deployment, analyses showed that the majority of respondents fell within a normal range for all cardiovascular risk categories at both pre- and post-deployment. Nevertheless, statistically significant changes were found between the mean pre- and post-deployment scores for BMI, diastolic blood pressure and cardiovascular fitness. However, these results need to be interpreted with caution as the changes were small and may be of limited clinical importance. Further, it should be noted that the blood pressure monitor used in this study (Appendix S) had a measurement error of plus or minus four millimetres of mercury, which is larger than the measured change in mean diastolic blood pressure.

The analyses presented in this chapter also showed that a small number of participants increased in risk categories between pre- and post-deployment. In particular, 8.2% of respondents moved from a normal waist-hip ratio to an obese waist-to hip ratio, 16.5% increased at least one BMI category, 22.0% increased at least one blood pressure category, and 59.2% had reduced (though still average) cardiovascular fitness as measured by the Queens College Step Test, between pre- and post-deployment.

Differences in diet while on deployment may be a contributory factor to small changes in waist-to-hip ratio and BMI scores. As the majority of respondents had been home for approximately four months, it is also possible that increases in weight may be due to the post-deployment lifestyle. However, while only small at this stage, these shifts may still be important, as small changes over the relatively short period of this study may represent a risk for a trajectory towards reduced cardiovascular health into the future. For example, small increases in BMI can indicate risk for emerging obesity in some individuals.

In addition, an analysis which considered the association between these cardiovascular health indices was included at the beginning of this chapter. This showed significant associations between all the indices, the strongest being between systolic and diastolic blood pressures. The associations between systolic and diastolic blood pressure and other indices were also similar in magnitude and direction. Therefore, diastolic and systolic blood pressures were combined into 'blood pressure' for the purposes of all further analyses in this chapter.

12.5.1 Associations

The changes in some cardiovascular health indices between pre- and postdeployment were significantly associated with a small number of factors. Length of current deployment, for example, was significantly associated with changes in BMI, blood pressure and cardiovascular fitness as measured by the Queens College Step Test. Role on most recent deployment and traumatic deployment exposures were associated with changes in cardiovascular fitness. Despite the emerging literature which suggests a relationship between psychological and physical health, there were no significant associations between the psychological co-morbidity groups identified at post-deployment (0, 1, 2 and 3 psychological conditions) and changes in any of the cardiovascular health indices measured by this study. In particular, the lack of associated increased blood pressure with increased alcohol consumption is not consistent with the suggested role of alcohol consumption in hypertension.

12.5.2 Time Away on Most Recent Deployment

This study did, however, find that a number of changes to cardiovascular indices were associated with time away on most recent deployment. For example, those respondents who had been deployed for six to seven months were significantly less likely to have a decrease in blood pressure compared to those who had been deployed for less than or equal to five months.

Furthermore, changes in BMI between pre- and post-deployment were less, on average, for those who were away on deployment for less than or equal to five months than for those who were away for six to seven months, eight months and nine to 12 months. In line with these findings, cardiovascular fitness was also likely to decrease the longer the time away on the most recent deployment.

At least one study has found no difference in blood pressure rates between deployed and non-deployed military personnel (22), while McCauley et al (23) and Granado et al (24) found that deployed personnel were more likely to have transient elevated blood pressure than non-deployed personnel. These authors also found that deployed personnel tended to have a *lower* incidence of newly diagnosed hypertension. While this appears anomalous, it is likely to reflect the medical health clearance personnel are required to undertake prior to deployment.

Deployment has also been shown to effect cardio-respiratory health. Forthergill and Sims (25) found a significant decrease in running performance of personnel from preto post-deployment in comparison to their non-deployed colleagues. While there were no within or between group differences in heart rate, heart rate *recovery* was also impaired at post-deployment for the deployed compared to non-deployed group. The authors concluded that exercise performance gives a better indication of aerobic conditioning than heart rate itself. Lester et al. (12) also found decreased aerobic performance, as well as increased BMI, in a sample of troops deployed to Iraq. Consistent with the results from this study, Sharp et al. (26) found that aerobic power and body strength decreased while body fat increased in a sample of US Army personnel who were deployed to Afghanistan for nine months. They proposed that this could reflect decreased exercise whilst on deployment. In contrast, Sim et al. (27) reported no significant differences between deployed Australian Gulf War veterans and a comparison group in weight, BMI, waist circumference, or measures of cardio-respiratory fitness.

12.5.3 Role on Most Recent Deployment

The only significant association between role on most recent deployment and a change in cardiovascular health between pre- and post-deployment was found for cardiovascular fitness as measured by the Queens College Step Test. In this instance the change in step test scores was significantly greater, on average, for those in a combat role or who operated outside of the main support base, and for those whose role was inside the main support base, compared to respondents who were based outside of Afghanistan in a support role.

To our knowledge, this is the first time a longitudinal study has found an association between changes in cardiovascular fitness as measured by the Queens College Step Test and deployment roles. However, Granado et al. (24) found that the incidence of newly diagnosed hypertension was significantly higher for those who were directly exposed to combat compared to those who were not, using data from the Millennium Cohort Study. While no association with blood pressure was found in this study, more generally, these findings support the argument that stress exposure (as indicated by combat exposures) may be implicated in changes to cardiovascular health.

12.5.4 Traumatic Deployment Experiences

In contrast to role on most recent deployment, a number of significant associations were found between traumatic experiences and changes to cardiovascular health. For example, statistically significant associations were found between human degradation and change in BMI between pre- and post-deployment. In addition, being in a vulnerable situation or fearing events, coming under fire, discharging one's own weapon, being in danger of being killed or injured, and having casualties among those close to one, were all significantly associated with a reduction in cardiovascular fitness as measured by Queens College Step Test, in comparison to respondents who did not report those exposures.

There was also an association between the number of traumatic exposures and changes to cardiovascular fitness as measured by the Queens College Step Test. The change in step test scores between pre- and post-deployment was significantly different between the four categories of deployment exposure (low 0 - 4, medium 5 - 16, high 17 - 35 and very high 36 - 104). Compared to those with the lowest number of deployment exposures, those in the medium, high and very high categories all had a greater increase in their step test score, indicating reduced fitness.

While previously published literature suggests that both transient increases in blood pressure (13), and diagnosed hypertension may be associated with combat exposure in military populations (15, 28), until now no association between combat exposure and BMI or cardiovascular fitness have been found. However, aerobic fitness itself may impact on stress responses, with evidence from a sample of US Navy personnel, showing that reduced physical fitness measured by the self reported results from a Physical Readiness test conducted by the military, was associated with a larger impact of stressful events (29). Furthermore, a review of the literature conducted by McGraw et al (1), found a positive relationship between stress exposure and cardiovascular disease incidence in the military.

Unlike findings from this study, the majority of research looking at the relationship between cardiovascular health and traumatic experiences in military populations have identified an association with blood pressure. While troops who deploy have in general been found to have a lower incidence of hypertension, deployment with multiple stressful combat exposures, especially witnessing a death because of war or disaster, appears to be a unique risk factor for newly reported hypertension (24). Stress related to high pressure work, natural disasters and missile attacks has been associated with increased myocardial infarction and other cardiovascular risk (30). Ermakova, Shpagina, Volkova, & lakovleva (14), for example, found that being exposed to chronic stress resulted in elevated blood pressure, while Shpagina, Ermakova, Volkova, & lakovleva (28) found a relationship between chronic stress exposure and diagnosed hypertension. It is hypothesised that the stress response brought about by violent combat exposure can lead to hypertension through various mechanisms including the release or inhibition of hormones that regulate blood pressure (e.g., cortocoids and prostoglandins) and arousal of the sympathetic nervous system (24). However, this did not appear to be the case in this study.

12.6 Summary

The majority of participants fell within a normal range for most of the indicators used to measure cardiovascular health in this chapter. The only exception was BMI where only 29.4% of participants met the criteria for normal BMI at post-deployment. There is evidence, however, that questions the accuracy of BMI as an indicator of obesity, primarily because it does not take into account the composition (2) or distribution (3) of body weight.

While the majority of participants in this study were healthy at post-deployment, there were significant associations between changes to some indicators between pre- and post-deployment and several factors related to the most recent deployment. Specifically, decreases in cardiovascular fitness as measured by the Queens College Step Test were associated with being away for between nine and twelve months on the most recent deployment, being in a combat role or operating outside of the main support base, as well as reporting a number of different types and a greater number of traumatic deployment experiences. In addition, BMI was associated with being away for more than five months on the most recent deployment, and being exposed to human degradation, although these findings should be treated with caution given the evidence that BMI may not be the most appropriate measure of obesity.

The next chapter in this section focuses on **respiratory health** (Chapter Thirteen). Once again, after providing a short introduction, the primary results are presented and discussed. Other chapters in this section include:

- Skin conditions, chapter fourteen
- Infectious Diseases in Chapter Fifteen
- **Biochemistry** in Chapter Sixteen

Further sections within this report focus on:

- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- Conclusions and Limitations are presented in Chapter Twenty Two

12.7 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the following questions should be considered:

- What factors are associated with different trajectories of cardiovascular health (decreasing, stable and increasing symptoms)?
- What is the impact of prior lifetime traumas reported at pre-deployment and changes to cardiovascular health between pre- and post-deployment?
- What are the potential reasons for variations in cardiovascular health between pre- and post-deployment length of most recent deployment?

12.8 References

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Chapter Thirteen – Respiratory Health

Key Points

- 1. The majority of participants who completed the lung function test in this study fall well **within the normal range for respiratory health**.
- 2. A small number of participants **met the Global Initiative for Chronic Obstructive Lung Disease criteria**.
 - Four participants at pre-deployment only.
 - Five participants at post-deployment only.
 - Four participants at both pre- and post-deployment.
- 3. There were also a small number of statistically significant changes between pre- and post-deployment significant which were associated with the **most recent deployment**.
- 4. Specifically, these **significant associations** were between small decreases in the lung function (and % predicted), and:
 - reporting exposure to between 17 and 35 different chemical and/or environmental exposures; and
 - reports of inhaling fine dust, aviation fuels and/or aircraft fumes.

This chapter presents and discusses the findings relating to objectively measured changes in respiratory health between pre- and post-deployment. The chapter begins by briefly discussing current literature pertaining to respiratory health in the military. Primary results are then provided, beginning with a comparison of the mean pre-deployment forced expiratory volume at one second (FEV1) scores, between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. All subsequent analyses, including forced vital capacity (FVC) and ratio of FEV1 and FVC include only those participants who completed both the pre- and post-deployment measures. The chapter concludes by discussing the primary findings pertaining to these objective measures of respiratory health. Findings pertinent to the focus of this chapter are also presented in Chapter Twenty One (Allostatic Load).

13.1 Introduction

Two issues of particular concern have been identified in the way in which previous studies have calculated the rate of respiratory disease within military populations. As many of studies have been based on cross-sectional designs, any respiratory health issues that were in existence before an exposure were not accounted for. Without this baseline data it is not possible to accurately assess the impact of specific exposures on a person's respiratory health [1].

In addition, many previous studies have used self report data to measure the impact of exposures on respiratory health. This type of measurement is open to recall bias, particularly when the data are collected well after exposures have occurred. An Institute of Medicines report updating the health effects of deployment to the Gulf War 1990-91 [2] draws attention to this issue. In particular, the IOM noted that while a number of studies based on self report data have found an excess of respiratory complaints in Gulf War veterans, studies using more objective measures of disease have not shown the same effect. The IOM concluded that there was, therefore, insufficient evidence to determine whether an association between deployment to the Gulf War 1990-91 and respiratory disease existed.

Non-specific respiratory symptoms are relatively common in the Australian population. In 2011, for example, the Australian Bureau of Statistics reported approximately 11,000 deaths associated with a respiratory condition, making respiratory disease the third most common cause of death in Australia (ABS, 2011). While asthma is common in younger members of the population, chronic lung diseases such as Chronic Obstructive Pulmonary Disease (COPD), resulting in a general narrowing or obstruction of the airways, does not usually become a problem until middle age or later life.

Significant environmental or occupational exposures, including those that may occur in the military, have been associated with early development of both asthma and COPD. For example, the uptake of tobacco smoking amongst military personnel, which is associated with a number of respiratory complaints, has been well documented [3-6]. In a recent study of more than 48,000 military personnel, 57% of the cohort started or increased their smoking as a result of deployment. While specific relationships have not been ascertained, this significant uptake was thought to relate to the stress encountered during deployment [6].

Deployment, in particular, has been found to be associated with an increased prevalence of non specific respiratory symptoms in a number of studies. Soltis et al. [7] found that it was common to have at least one respiratory infection while deployed. A study of US troops returning from either Iraq or Afghanistan between 2003 and 2004 also found that over 50% reported suffering at least one respiratory illness during their deployment [8].

Despite the evidence suggesting deployment may impact directly on respiratory health, specific exposures, rather than deployment in general, may determine post-deployment respiratory illness [9]. Specific combat related exposures may, for example, be related to lung damage. A recent study found that a number of patients were found to have developed adult respiratory distress syndrome as a result of blast injury [10].

A working group formed to consider lung disease in returning US war fighters [11] has identified a number of potential risks for the development of lung disease postdeployment. These include type, severity and duration of exposure to environmental hazards, deployment for extended periods and/or multiple times, proximity and duration of exposure to burn pits or fires, and frequency of exposure to desert dust storms.

13.2 Measures

The following objective measures of respiratory health were collected as part of both the pre- and post-deployment physical testing component of the study (see Appendix

D). The spirometer was developed in the early 19th century to assess damage to lung function, and military personnel were among the first to undergo spirometry testing [12]. The assessment of pulmonary function using spirometry is not only useful for the differential diagnosis of respiratory disease including asthma, but also has the capacity to assess disability.

This study reports three objective measures of respiratory health collected through spirometry:

- forced expiratory volume at one second (FEV1),
- forced vital capacity (FVC); and
- FEV1 and FVC ratio (FEV/FVC).

The findings presented within this chapter also address the **percentage predicted for FEV1, FVC and FEV1/FVC**. Percentage predicted presents the result as a percent of the "predicted values" for the participant, given their height, age and sex. Therefore, 95% predicted percentage for FEV1 would equate to a participant having 95% of their expected expiratory volume at one second, given their height, age and sex.

13.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and changes to objective measures of respiratory health between pre- and post-deployment?
- 2. Is there an association between **chemical and environmental exposures** on most recent deployment and changes to objective measures of respiratory health between pre- and post-deployment?
- 3. Is there an association between a **change in tobacco usage** and changes to objective measures of respiratory health between pre- and post-deployment?
- 4. Is there an association between the **total time away on previous deployments in the last three years** and changes to objective measures of respiratory health between pre- and post-deployment?
- 5. Is there an association between **number of previous deployments** and changes to objective measures of respiratory health between pre- and post-deployment?
- 6. Is there an association between the **psychological co-morbid groups** and changes in cardiovascular indices between pre- and post-deployment?

13.2.2 Sample Sizes

The total sample size used **to identify change in objective measures** of respiratory health between pre- and post-deployment was 202. Of the 399 participants who completed both a pre- and a post-deployment physical test 197 were excluded because:

- 53 participants did not complete spirometry at pre-deployment,
- 22 did not complete spirometry at post-deployment,
- 4 physical testing participants did not complete spirometry at both pre- and postdeployment; and
- 50 pre-deployment, 28 post-deployment and 40 pre- and post-deployment tests were completed, but upon review by the Professor of Clinical Respiratory Physiology at the University of South Australia, were deemed not to meet the

ATS/ERS 2005 criteria [13] for valid spirometry, and were therefore excluded from the analyses.

The total sample size used **to compare pre- deployment objective respiratory health** for pre-deployment only physical testing participants, with pre- and postdeployment physical testing participants, was 156. Of the 202 participants who completed a pre-deployment physical test only, 41 participants did not complete the spirometry test at pre-deployment, and a further 59 tests were deemed not to be of sufficient quality for analysis, thus were also excluded from the analyses.

13.2.3 Data Analysis

A mixed model for repeated measures was used to analyse continuous FEV1, FVC and FEV1/FVC ratio measures. This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post-deployment) and their interaction(s) are included as fixed effects in the model.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences.

13.3 Results

Pre-deployment mean FEV1 scores were not significantly different (p = 0.59) between respondents who only completed a pre-deployment physical tests compared to those who completed both pre- and post-deployment physical tests (Table 13.1, Appendix T). For respondents who completed spirometry at both pre- and post-deployment, the mean FEV1 scores were 4.4 and 4.3 respectively (change = -0.1, 95% CI -0.1, 0.0), and this decrease was small but significant (p = 0.0012) (Table 13.2, Appendix T). A summary of the FEV1 percent predicted for the total sample is also presented in Table 13.3 (Appendix T).

Pre-deployment mean FVC scores were not significantly different (p=0.55) for respondents who only completed a pre-deployment physical test compared to those who completed both pre- and post-deployment physical tests (Table 13.4, Appendix T). For respondents who completed spirometry at both pre- and post-deployment, the mean FVC scores were 5.4 and 5.3 respectively (change = -0.1, 95% CI -0.1, 0.0), and this decrease was small but significant (p = 0.0097) (Table 13.5, Appendix T). A summary of the FVC percent predicted for the total sample is also presented in Table 13.6 (Appendix T).

Pre-deployment mean FEV1/FVC scores were not significantly different (p=0.93) between respondents who only completed a pre-deployment physical test compared to those who completed both pre- and post-deployment physical tests (Table 13.7, Appendix T). For respondents who completed spirometry at both pre- and post-deployment, the mean FEV1/FVC scores were 80.4 and 80.0 respectively (change = -0.4, 95% CI -0.8, 0.1), and this difference was not significant (p = 0.10) (Table 13.8, Appendix T).

Table 13.9 summarises the number of respondents in each percent predicted risk category at pre- and post-deployment.

Table 13.9: Summary of changes to FEV1, FVC and Ratio risk categories between pre- and post	-
deployment.	

Risk Categories	None	Pre- only	Post- Only	Pre- and Post-
EEV(1 producted (< 80%))	168	7	15	12
revi predicted (< 80%)	83.2%	3.5%	7.4%	5.9%
EVC prodicted (< 80%)	201		1	
FVC predicted (< 80%)	99.5%		0.5%	
	189	4	5	4
	93.5%	2.0%	2.5%	2.0%

The majority of responders (93.5%) did not change FEV1/FVC ratio risk category between pre- and post-deployment, and only 2% of responders were in the high risk category for FEV1/FVC ratio at both pre- and post-deployment (Table 13.10, Appendix T).

13.3.1 Length of Most Recent Deployment

13.3.1.1 FEV1

The mean changes to FEV1 between pre- and post-deployment for the different 'Length of recent deployment' categories (and % predicted) are presented in Table 13.11.

Length of current deployment (months)	N		Pre- deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% CI)
≤5 months	48	FEV1	4.30	4.24	-0.06
			(4.12, 4.40)	(4.00, 4.42)	(-0.13, 0.03)
		%	93.00	91.73	-1.27
		Predicted	(90.06, 95.94)	(88.78, 94.67)	(-3.22, 0.67)
6 or 7 months	69	FEV1	4.39	4.26	-0.13
			(4.24, 4.54)	(4.11, 4.41)	(-0.21, -0.05)
		%	94.05	91.25	-2.80
		Predicted	(91.59, 96.50)	(88.79, 93.70)	(-4.42, -1.17)
8 months	59	FEV1	4.39	4.23	-0.16
			(4.23, 4.55)	(4.07, 4.40)	(-0.24, -0.07)
		%	95.13	91.71	-3.42
		Predicted	(92.58, 97.78)	(89.05, 94.36)	(-5.18 <i>,</i> -1.67)
9-12 months	26	FEV1	4.28	4.48	0.20
			(4.04, 4.53)	(4.23, 4.72)	(0.07, 0.32)
		%	89.29	93.20	3.91
		Predicted	(85.30, 93.29)	(89.20, 97.20)	(1.26, 6.55)

Table 13.11: Change in mean FEV1 and % predicted for each leng	th of recent deployment.
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As can be seen in Table 13.11, there was a significant difference in the change in FEV1 (and % predicted) from pre- and post-deployment, between the categories of

recent length of deployment (p<0.0001). FEV1 (and % predicted) increased between pre- and post-deployment for those who were away for 9-12 months (p=0.0028). For those deployed for 6 or 7 months (p=0.001) and 8 months (p=0.0003), FEV1 (and % predicted) significantly decreased between pre- and post-deployment. There was no significant change in FEV1 (and % predicted) between pre-and post-deployment for those who were deployed for 5 months or less (p=0.21) (Figure 13.1).



Figure 13.1: Mean FEV1 at each deployment time for each category of length of recent deployment

13.3.1.2 FVC

The mean changes to FVC between pre- and post-deployment for the different 'Length of recent deployment' categories are presented in Table 13.12.

Length of current deploy (months)	N		Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
≤5 months	48	FVC	5.43	5.36	-0.07
			(5.21, 5.65)	(5.15, 5.15, 5.58)	(-0.18, 0.05)
		%	117.33	115.97	-1.36
		predicted	(113.86, 120.80)	(112.43, 119.51)	(-3.75, 1.03)
6 or 7	69	FVC	5.50	5.34	-0.16
months			(5.32, 5.68)	(5.16, 5.52)	(-0.25, -0.06)
		%	117.73	114.41	-3.32
		predicted	(114.83, 120.63)	(111.45, 117.36)	(-5.31, -1.33)
8 months	59	FVC	5.43	5.30	-0.13
			(5.23, 5.62)	(5.10, 5.49)	(-0.23, -0.03)

Tabla	12 12	Chaman	1		. In manufic the set	fanaah	الم مالية مرا			
rable	15.1Z	Change	in mean	FVC and %	predicted	ior each	iength of	current	debiovi	ment

		%	117.72	114.82	-2.90
		predicted	(114.59 <i>,</i> 120.85)	(111.62, 118.01)	(-5.05 <i>,</i> -0.75)
9-12 months	9-12 months 26 FVC		5.26	5.50	0.24
			(4.97, 5.56)	(5.20, 5.79)	(0.08, 0.39)
		%	109.54	114.27	4.73
		predicted	(104.82, 114.27)	(109.46, 119.08)	(1.48, 7.97)

As can be seen in Table 13.12, there was a significant difference in the change in FVC (and % predicted) from pre- and post-deployment, between length of recent deployment categories (p=0.0004). FVC (and % predicted) increased between preand post-deployment for those who were away for 9-12 months (p=0.0038). For those deployed for 6 or 7 months (p=0.001) and 8 months (0.014), FVC (and % predicted) significantly decreased. There was no significant change in FVC (and % predicted) between pre-and post-deployment for those who were deployed for 5 months or less (p=0.28) (Figure 13.2).



Figure 13.2: Mean FVC at each deployment time for each category of length of recent deployment

13.3.1.3 FEV1/FVC

The mean changes to FEV1/FCV between pre- and post-deployment for the different 'Length of recent deployment' categories are presented in Table 13.13 (Appendix T). As can be seen in this table, there was no significant association between length of recent deployment and change in FEV1/FVC ratio (and % predicted).

13.3.2 Number of Chemical and Environmental exposures

An analysis of associations between respiratory health and total number of chemical and environmental exposures on most recent deployment was also undertaken. A total score based on the 10 exposures was calculated and categorised, where 'Low' = 14 or less times, 'Medium'=15-23, 'high' = 24-29, 'very high exposure' = 30-40.

13.3.2.1 FEV1

The mean change in FEV1 (and % predicted) between pre- and post-deployment for the different numbers of chemical and environmental exposures are presented in Table 13.14 (Appendix T) As can be seen in this table, there was no significant association between the number of chemical and environmental exposures and mean change in FEV1 (and % predicted).

13.3.2.2 FVC

The mean change in FVC (and % predicted) between pre- and post-deployment for the different numbers of chemical and environmental exposures are presented in Table 13.15 (Appendix T). As can be seen in this table, there was no significant association between the number of chemical and environmental exposures and mean change in FVC (and % predicted).

13.3.2.3 FEV1/FVC

The mean change in FEV1/FVC ratio (and % predicted) between pre- and postdeployment for the different numbers of chemical and environmental exposures are presented in Table 13.16.

Chemical Exposure (categories)	N		Pre-deployment (95% Cl)	Post- deployment (95% Cl)	Change (95% CI)
Low	25	FEV1/FVC	80.24	82.05	1.81
			(78.12, 8.35)	(80.07, 84.04)	(0.57, 3.06)
		%	96.31	98.52	2.21
		predicted	(93.91, 98.70)	(96.27 <i>,</i> 100.76)	(0.72, 3.70)
Medium	30	FEV1/FVC	81.62	81.11	-0.51
			(79.69 <i>,</i> 83.55)	(79.29, 82.92)	(-1.65, 0.62)
		%	96.83	96.22	-0.61
		predicted	(94.65 <i>,</i> 99.02)	(94.17 <i>,</i> 98.26)	(-1.98, 0.74)
High	54	FEV1/FVC	81.02	79.95	-1.07
			(79.58 <i>,</i> 82.46)	(78.60, 81.30)	(-1.92, -0.22)
		%	96.60	95.32	-1.28
		predicted	(94.97 <i>,</i> 98.23)	(93.79 <i>,</i> 96.85)	(-2.29, -0.26)
Very High	67	FEV1/FVC	80.10	79.42	-0.68
			(78.81, 81.40)	(78.21, 80.64)	(-1.44, 0.08)
		%	95.66	94.85	-0.81
		predicted	(94.19, 97.12)	(93.48, 96.22)	(-1.72, 0.10)

Table 13.16: Mean (95% CI) change in FEV/FVC (and % predicted) for each number of chemical and
environmental exposures.

As can be seen in Table 13.16, the change in FEV1/FVC (and % predicted) from preto post-deployment, was significantly different between the numbers of chemical and environmental exposures (p=0.002). FEV1/FVC (and % predicted) increased between pre- and post-deployment for those who had a low number of exposures (p=0.004). While for those who had high numbers of exposures, FEV1/FVC (and % predicted) significantly decreased between pre- and post-deployment (p=0.01). There was no significant change in FEV1/FVC (and % predicted) for those who had medium (p=0.37) and very high (0.08) numbers of chemical exposures (Figure 13.3).



Figure 13.3: Mean FEV1/FVC Ratio at each deployment time for each category of number of chemical and environmental exposures.

13.3.3 Types of Chemical and Environmental Exposures Reported

An analysis of associations between respiratory health and chemical and environmental exposures on most recent deployment was undertaken. Smoke from fires, dust storms and inhaled fine dust fibres were the most commonly reported chemical and environment exposures. Note that each respondent could have responded positively to more than one exposure.

13.3.3.1 FEV1

The mean change in FEV1 (and % predicted) between pre- and post-deployment for the different chemical and environmental exposures are presented in Table 13.17 (Appendix T). As can be seen from this table, there were no significant associations between any of the chemical and environmental exposures and change in FEV1 (and % predicted) between pre- and post-deployment.

13.3.3.2 FVC

The mean change in FVC (and % predicted) between pre- and post-deployment for the different chemical and environmental exposures are presented in Table 13.18 (Appendix T). As can be seen from this table, there were no significant associations between any of the chemical and environmental exposures and change in FEV1 (and % predicted) between pre- and post-deployment.

13.3.3 FEV1/FVC

The mean change in FVC (and % predicted) between pre- and post-deployment for the different chemical and environmental exposures are presented in Table 13.19.

Chemical and		Exposed		Unexposed		
Environmental Exposures	Number (%)	Change FEV1/FVC (95% CI)	Change FEV1/FVC % Predicted (95% Cl)	Number (%)	Change FEV1/FVC Scores (95% CI)	Change FEV1/FVC % Predicted (95% Cl
Smoke from fires	165 (93.7%)	-0.49 (-0.99, 0.01)	-0.58 (-1.18, 0.02)	11 (6.3%)	0.69 (-1.26, 2.63)	0.86 (-1.47, 3.18)
Dust storms	161 (91.5%)	-0.54 (-1.05, -0.04)	-0.64 (-1.24, -0.03)	15 (8.5%)	0.92 (-0.73, 2.58)	1.10 (-0.88, 3.07)
Inhaled fine dust fibres	162 (92.1%)	-0.59 (-1.09, -0.09)	-0.70 (-1.30, -0.10)	14 (7.9%)	1.63 (-0.07, 3.33)	1.94 (-0.09, 3.98)
Others' cigarette smoke	143 (81.3%)	-0.60 (-1.13, -0.06)	-0.71 (-1.36, -0.07)	33 (18.7%)	0.37 (-0.75, 1.49)	0.47 (-0.87, 1.81)
Diesel exhaust	167 (96.0%)	-0.53 (-1.02, -0.04)	-0.64 (-1.23, -0.05)	7 (4.0%)	2.67 (0.27, 5.07)	3.36 (0.49, 6.23)
Aviation, marine or automotive fuel	144 (82.3%)	-0.79 (-1.31, -0.26)	-0.94 (-1.57, -0.31)	31 (17.7%)	1.26 (0.13, 2.39)	1.54 (0.19, 2.89)
Aircraft fumes	154 (88.0%)	-0.73 (-1.23, -0.22)	-0.87 (-1.47, -0.26)	21 (12.0%)	1.79 (0.42, 3.16)	2.18 (0.55, 3.82)
Toxic industrial chemicals	88 (50.9%)	-0.29 (-0.98, 0.40)	-0.34 (-1.17, 0.48)	85 (49.1%)	-0.53 (-1.23, 0.17)	-0.62 (-1.46, 0.22)
Solvents (e.g. thinners, sealer, paints)	103 (59.2%)	-0.46 (-1.10, 0.17)	-0.55 (-1.32, 0.21)	71 (40.8%)	-0.39 (-1.16, 0.38)	-0.45 (-1.37, 0.47)
Live in an area recently sprayed	52 (30.1%)	-0.48 (-1.38, 0.42)	-0.58 (-1.66, 0.50)	121 (69.9%)	-0.42 (-1.01, 0.17)	-0.49 (-1.20, 0.22)

Table 13.19: Mean (95% CI) change in FEV1/FVC ratio (and % predicted) for each chemical and environmental exposure.

For those who were exposed to inhaled fine dust (p=0.01), aviation fuels (p=0.001) and aircraft fumes (p=0.0008) the change in FEV1/FVC ratio between pre- and post-deployment was significantly greater compared to those who did not report those exposures. The change in % predicted was also greater for those who were exposed to inhaled fine dust (0.007), aviation fuels (0.001) and aircraft fumes (p=0.0007), compared to those who were not.

13.3.4 Smoking Status

13.3.4.1 FEV1

The mean change in FEV1 (and % predicted) between pre- and post-deployment for the different 'Smoking status' categories are presented in Table 13.20 (Appendix T). As can be seen in this table, there was no significant association between smoking status and change in FEV1 (and % predicted).

13.3.4.2 FVC

The mean change in FVC (and % predicted) between pre- and post-deployment for the different 'Smoking status' categories are presented in Table 13.21 (Appendix T). As can be seen in this table, there was no significant association between smoking status and change in FVC (and % predicted).

13.3.4.3 FEV1/FVC

The mean change in FEV1/FVC (and % predicted) between pre- and postdeployment for the different 'Smoking status' categories are presented in Table 13.22 (Appendix T). As can be seen in this table, there was no significant association between smoking status and change in FEV1/FVC (and % predicted).

13.3.5 Smoking Behaviour

13.3.5.1 FEV1

The mean change in FEV1 (and % predicted) between pre- and post-deployment for the different 'Smoking behaviour' categories are presented in Table 13.23 (Appendix T). As can be seen in this table, there was no significant association between smoking behaviour and change in FEV1 (and % predicted).

13.3.5.2 FVC

The mean change in FVC (and % predicted) between pre- and post-deployment for the different 'Smoking behaviour' categories are presented in Table 13.24 (Appendix T). As can be seen in this table, there was no significant association between smoking behaviour and change in FVC (and % predicted).

13.3.5.3 FEV1/FVC

The mean change in FEV1/FVC ratio (and % predicted) between pre- and postdeployment for the different 'Smoking behaviour' categories are presented in Table 13.25 (Appendix T). As can be seen in this table, there was no significant association between smoking behaviour and change in FEV1/FVC (and % predicted).

13.3.6 Total Time on prior deployments

13.3.6.1 FEV1

The mean changes to FEV1 between pre- and post-deployment for the different 'Time on prior deployment' categories are presented in Table 13.26 (Appendix T). As can be seen in this table, there was no significant association between time on prior deployments and change in FEV1 (and % predicted).

13.3.6.2 FVC

The mean changes to FVC between pre- and post-deployment for the different 'Time on prior deployment' categories are presented in Table 13.27 (Appendix T). As can be seen in this table, there was no significant association between time on prior deployments and change in FVC (and % predicted).

13.3.6.3 FEV1/FVC

The mean changes to FEV1/FVC between pre- and post-deployment for the different 'Time on prior deployment' categories are presented in Table 13.28 (Appendix T). As can be seen in this table, there was no significant association between time on prior deployments and change in FEV1/FVC (and % predicted).

13.3.7 Number of prior deployments

13.3.7.1 FEV1

The mean changes to FEV1 between pre- and post-deployment for the different 'Number of prior deployment' categories are presented in Table 13.29 (Appendix T). As can be seen in this table, there was no significant association between number of prior deployments and change in FEV1 (and % predicted).

13.3.7.2 FVC

The mean changes to FVC between pre- and post-deployment for the different 'Number of prior deployment' categories are presented in Table 13.30 (Appendix T). As can be seen in this table, there was no significant association between number of prior deployments and change in FVC (and % predicted).

13.3.7.3 FEV1/FVC

The mean changes to FEV1/FVC between pre- and post-deployment for the different 'Number of prior deployment' categories are presented in Table 13.31 (Appendix T). As can be seen in Table 13.31, there was no significant association between number of prior deployments and change in FEV1/FVC (and % predicted).

13.3.8 Psychological Co-Morbidity

13.3.8.1 FEV1

The mean changes to FEV1 between pre- and post-deployment for the different categories of psychological co-morbidity are presented in Table 13.32 (Appendix T). As can be seen in this table, there was no significant association between number of psychological conditions and change in FEV1 (and % predicted).

13.3.8.2 FVC

The mean changes to FEV1 between pre- and post-deployment for the different categories of psychological co-morbidity are presented in Table 13.33 (Appendix T). As can be seen in this table, there was no significant association between number of psychological conditions and change in FVC (and % predicted).

13.3.8.3 FEV1/FVC

The mean changes to FEV1/FVC ratio between pre- and post-deployment for the different categories of psychological co-morbidity are presented in Table 13.34 (Appendix T). As can be seen in this table, there was no significant association between number of psychological conditions and change in FEV1/FVC (and % predicted).

13.4 Summary of Results

Table 13.35 summarises the key findings presented in this results section in relation to the questions posed in Section 13.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Table 13.35: Summary of	key findings presented in this chapter

Question	Significant Associations
Q1. Length of most recent deployment	There was no significant change in measures of respiratory health between pre- and post-deployment for those participants deployed for <= 5months. Those deployed for 9-12 months had a small increase in lung function, while those away for 6-7 months or 8 months, had a small decrease in lung function.
Q2. Role on most recent deployment	Nil
Q3a. Number of chemical and environmental exposures	There was a statistically significant decrease in lung function between pre- and post-deployment for those with high numbers of chemical and environmental exposures, and a small increase in lung function for those who had a low number of exposures. There was no significant change for those who had medium and very high numbers of chemical exposures
Q3b. Types of	For those who were exposed to inhaled fine dust, aviation fuels
chemical and	and aircraft fumes, there was a greater decrease in lung function
environmental exposures	between pre- and post-deployment, compared to those who were not exposed
Q4a. Changes in smoking status	Nil
Q4b. Changes in smoking behaviour	Nil
Q5. Number of prior deployments	Nil
Q6. Co-morbidity at post-deployment	Nil

13.5 Discussion

The majority of participants fall well within the normal range for respiratory health. Based on the predicted value at post-deployment, only 13.3% of participants had an abnormal FEV1 result, 0.5% of participants had an abnormal FVC result and 4.5% of participants had an abnormal FEV1/FVC result. All of the changes in FEV1, FVC and FEV1/FVC ratio between pre- and post-deployment were relatively small and well below the repeatability criteria, and therefore unlikely to be of physiological importance in the short term.

In addition, small but significant decreases between pre- and post-deployment were found for both FEV1 and FVC measures. However, these findings should be interpreted with caution as the as the changes were small and may be of limited clinical importance.

This finding is in contrast to results from other studies involving the general Australian population, which suggest that respiratory illness including non-specific respiratory symptoms, are relatively common. A random sample of 20 - 40 year olds living in Melbourne in the early 1990's, for example, found that 28.6% reported a nocturnal cough, 28.6% wheezing, 15.6% breathlessness associated with wheezing, and 11.3% nocturnal shortness of breath [14]. More recently, in 2010 the Australian Bureau of Statistics reported respiratory disease to account for 8.3% of all deaths in Australia [15].

Asthma, a chronic inflammation of the airways, continue to be a significant health problem for the Australian health system, and prevalence rates continue to climb at a far more rapid rate than in other developed countries. Several cross-sectional studies conducted in Western Australia have found that the prevalence of doctor diagnosed asthma, for example, has increased significantly over the past 10 years. While only approximately 6% of those surveyed between 1966 and 1975 had been diagnosed with asthma, this had risen to 8% by 1981 and then 19% in 2005-2007 [16].

Nevertheless, only eight ADF personnel in this study had a FEV1/FVC ratio compatible with the GOLD criteria for airway obstruction prior to deployment. In addition, only four of these eight still met these criteria at post-deployment. However, an additional five personnel met GOLD criteria for airway obstruction only at post-deployment suggesting a newly acquired condition.

It should also be noted that some of the small changes in lung function may be confounded by age, since there is an expected and observed increase in lung function capacity up until approximately 25 years of age. The long term implications of deployment and exposures on respiratory health can only, therefore, be addressed by ongoing surveillance of the cohort. The rate of decline in FEV1 after the age of 25 years would be an important observation in the future, particularly as numerous studies have shown that exposure to cigarette smoke results in an accelerated decline [17, 18].

13.5.1 Associations

While the majority participants who completed spirometry appear not to be at any risk of lung disease, the small changes that did occur between pre- and post-deployment were found to be significantly associated with the length of the most recent deployment. In addition, a significant decrease in the FEV1/FVC ratio between pre- and post-deployment was found for those participants who reported particular exposures related to their last deployment, and also those who reported between 17 and 35 chemical and/or environmental exposures related to the last deployment. However, this last finding should be treated with caution as, surprisingly the same significant association was not found for those who reported more than 35 exposures.

13.5.2 Length of Most Recent Deployment

Data from the Millennium Cohort Study have also been used to identify the prevalence of new onset respiratory illness post-deployment [9]. Similar to findings from this study, results showed that while there was no increase in reported asthma, chronic bronchitis or emphysema, there was a relationship between length of deployment and respiratory symptoms for army personnel. Specifically, the longer an

individual was deployed, the more likely they were to report respiratory symptoms. The authors suggest that deployment may increase the risk of acute and short-term respiratory conditions for some personnel. It is not possible, however, to identify whether these symptoms will continue or increase over time.

Other studies have found that deployment per se is a risk factor for respiratory illness. A study of US troops returning from either Iraq or Afghanistan between 2003 and 2004 (n = 15,459) presented figures that suggested that approximately 69% of their cohort, reported suffering at least one respiratory illness during their deployment. In approximately 17% of these cases the individuals had sought specific medical care and 2% of these had been diagnosed with mild pneumonia [8]. The higher than expected rates of respiratory illness observed in this US study may, however, have been due to the increased pace of operations, along with a possible breakdown in the provision of clean food and water.

In comparison, other studies have found no clear effect of deployment, number of deployments or length of time deployed, on respiratory health. An Australian study by Kelsall et al. [19] found that while in comparison to a non-deployed control group, 1991 Australian Gulf War veterans reported higher rates of all respiratory symptoms, this was not confirmed by objective assessments which similar to this study also used a spirometer. Furthermore, a large review of medical records for nearly one million US military personnel found that relative to a single deployment, personnel who had been on multiple deployments were not significantly more likely to be diagnosed with obstructive pulmonary disease (OR 1.08; 95% confidence interval, 0.82 to 1.42). Neither was there any significant association between cumulative time deployed and obstructive pulmonary disease [20].

13.5.3 Chemical and Environmental Exposures

Specific exposures, rather than deployment in general, may determine postdeployment respiratory illness. An analysis of data from the Millennium Cohort Study, for example, found that land-based deployees were more likely (OR 1.73: CI 95%, 1.57, 1.91) in comparison to sea-based deployees (OR 1.49: CI 95% 1.06, 2.08) to develop respiratory symptoms and or be diagnosed with a respiratory disease such as asthma [9]. Similar to this study, exposures such as dust from the sand, smoke from the burn pits, aerosolized metals and chemicals from exploded IEDs, blast overpressure or shock waves to the lungs, outdoor aeroallergens such as date pollen, and indoor aeroallergens such as mould aspergillums, were believed to contribute to this increase. Subsequent animal studies demonstrated that exposing mice to samples of dust taken from Iraq and Afghanistan produced an extreme histological response [21].

It is perhaps not surprising that the results from this study show that the majority of participants did not suffer with respiratory illness after deployment. While no regular or on-going air quality monitoring is currently being undertaken by the ADF at this time, ADF personnel are often co-located with Allied forces on multi-national bases where personnel possessing the skills and equipment to carry out environmental health monitoring are also situated. The results of these assessments are shared with other coalition forces in the region.

One such assessment was conducted in Kabul by the Canadians in 2006 [22]. The results showed that the risk of adverse health effects from the inhalation of airborne metals, crystalline silica, as well as sulphur and nitrogen dioxides was considered to be negligible. The report also referred to subsequent monitoring of air, soil and water quality by Allied Nations, which indicated no significant environmental, industrial or operational health risks. Air monitoring, in central Afghanistan Kabul Area by the US

Army Public Health Command (US Army Centre for Health Promotion and Preventive Medicine) [23], also found the risk estimate for exposure to particulate matter less than 2.5nm in diameter, and metals in the ambient air at Camp Phoenix, Afghanistan, to be low.

Monitoring of ambient air particulate matter conducted by the USA CHPPM (March to April 2009) at Camp Eggers, Afghanistan, did, however, find a moderate occupational and environmental risk for exposure to particulate matter and metals. The conclusion from the report suggested that the air quality posted a significant health concern to susceptible groups such as asthmatics or persons with pre-existing cardio-pulmonary disease, but not other personnel. Predicted effects on soldiers' health include eye, nose and throat irritation, were unlikely to impact on operational capability [24].

The main sources of degraded air quality at the multinational base at Tarin Kowt were unsealed roads, use of diesel generators and the "burn pits" used to incinerate solid waste. The environmental health assessment report [25] refers to previous reports which identified the refuse burn pits as a potential threat to ambient air quality. The assessment conducted in October 2011, noted that the burn pit had subsequently been reduced in size and was better managed in comparison to previous inspections. As the burn pits are located external to the main operations area of the base, the likelihood of excessive exposure or significant ambient air quality was considered to be minimal. However, the POEMS Report [26, 27] identified inhalable coarse particulate matter and burn pits as potential health threats to personnel working in and around Kandahar. This report suggested that exposure to these would only result in short-term health effects (e.g., eye, noise or throat and lung irritation) in some personnel while at this site.

13.6 Summary

Apart from eight participants at pre-deployment and nine participants at postdeployment who met the GOLD criteria for obstruction, the findings show that the respiratory health of this sample was well within the normal range. There were small changes in respiratory health between pre- and post-deployment which were associated with the length of deployment and reports of chemical and/or environmental exposures. However, it is important to note that these small changes were not clinically significant.

The next chapter in this section focuses on **skin conditions** (Chapter Fourteen). Once again, after providing a short introduction, the primary results are presented and discussed. Other chapters in this section include:

- Infectious Diseases in Chapter Fifteen
- **Biochemistry** in Chapter Sixteen

Further sections within this report focus on:

- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- **Conclusions and Limitations** are presented in Chapter Twenty Two

13.7 Other Chapters of Relevance

• Chapter Twenty One – Allostatic Load

13.8 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, the associations with self-reported respiratory health and doctor diagnosed respiratory conditions should be investigated.

13.9 References

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Chapter Fourteen – Skin Conditions

Key Points

- 1. There was **no evidence of changes to skin conditions** as a result of the most recent deployment for the majority of participants who completed both pre- and post-deployment photography.
- 2. There was evidence of pre-existing skin conditions, which were present at both pre- and post-deployment, including:
 - acne (32.7%),
 - sun damage (29.7%); and
 - tinea (6.8%).

This chapter presents and discusses the findings relating to changes to skin conditions between pre- and post-deployment, specifically focussing on dermatitis, psoriasis, acne, skin lesions and secondary skin rashes. The chapter begins by briefly discussing current literature pertaining to the types of dermatological conditions which have previously challenged military populations. Results are then provided, beginning with a comparison between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment skin photography. The chapter concludes by discussing the primary findings pertaining to skin conditions in this particular sample.

14.1 Introduction

Deployments often occur in countries where environmental conditions, such as extreme heat or cold, dampness, and trauma, have significant potential to increase the risk of skin problems [1]. These environmental factors are an important cause of dermatological morbidity for land warfare. In the two World Wars, for example, dermatological conditions such as trench foot were the scourge of the Western Front due to the wet and mud [2]. In addition to being plagued with ulcers and tinea in tropical locations, Vietnam veterans also had to deal with specific skin conditions arising from exposure to Agent Orange [3, 4].

Specific complaints regarding dermatological symptoms such as skin rashes were also received after the Gulf War 1990-91. Veterans attributed these to toxic exposures while on deployment [5]. A UK study comparing troops deployed to the Gulf War 1990-91 with a non-deployed control group found that 36.7% of veterans still had a dermatological disorder 8-10 years after the end of the conflict; however, seborrheic dermatitis was the only diagnosed condition to occur more commonly among the veterans who had been deployed [6]. In comparison, a US study found that there were large increases in the rates of diagnosed atopic dermatitis and warts in personnel deployed to the Gulf War 1990-91 compared with their non-deployed counterparts [7].

A number of studies have also demonstrated an increase in self-reported skin conditions among Gulf War 1990-91 veterans. For example, self-reported dermatological problems were significantly more common in Australian Gulf War veterans compared to their non-deployed military colleagues [8]. Although skin examinations were undertaken in the Australian Gulf War study, these findings were not included in the study report [9]. A UK study also found that Gulf War 1990-91 veterans were significantly more likely to report dermatological conditions such as dermatitis, compared to those deployed to Bosnia, or non-deployed personnel [10]. The Institute of Medicine Report concluded, therefore, that while there was suggestive evidence of an association between deployment to a war zone and skin conditions, more research was needed [4].

Troops deployed to the more recent conflicts in Iraq and Afghanistan may be at a greater risk than veterans from the Gulf War 1990-91, as more military personnel are involved in land-based deployments. Cutaneous leishmaniasis, for example, which is endemic in the Middle East, can lead to severe skin ulcers with the potential for considerable scarring. Already, one percent of US soldiers returning from Iraq have been diagnosed with cutaneous leishmaniasis, with most of those affected having served in northern Iraq [11].

Psychological trauma has also been shown to have a significant association with skin conditions in military populations [12]. O'Toole et al [13] studied Australian veterans deployed to the Vietnam War over two decades after their combat related service. Combat exposure was positively associated with self-reported chronic "rash", although the relationship just failed to reach significance with eczema. In 1987, Eisen et al. [14] examined a cohort of twins where one had served in the Vietnam War. Severe acne and rashes were more than twice as likely to occur in the twin who served in Vietnam compared to their sibling. Further, the strength of this association increased with greater degrees of combat exposure.

PTSD and its associated neurobiological dysregulation may also increase the risk of dermatological conditions. Barrett et al. [15] used a case control design and found that dermatological complaints were present in over 90% of Gulf War 1990-91 veterans with PTSD in contrast to 25% of veterans without PTSD. Similarly, the Veterans Health Study, which examined consecutive male ambulatory patients, found that dermatitis was more common in veterans with PTSD (OR 2.37, 95% CI 1.88-3.0) [16]. While another study did not find this association when a number of demographic variables were controlled for [17], further analysis which specifically looked at the link between autoimmune disease and PTSD, found that psoriasis was nearly five times more common in Vietnam Veterans with PTSD than those without [18].

Non-specific hazards which are of concern to civilians may also be an issue for military populations [19]. For example there are a variety of specific bacterial and parasitic pathogens [20] that lead to skin disease. In addition, skin cancers as a result of sun exposure [21], and contact dermatitis [22] as a result of wearing a uniform and/or protective equipment [23], have been shown to be particularly problematic. Dermatological problems commonly present to medical services while on deployment [19, 24, 25]. These acute conditions still need to be considered when identifying the immediate hazards of deployment and its impact on health.

Nevertheless, these more acute issues need to be distinguished from any longer term effects that may result from military service. While a number of studies have attempted to do this, much previous research, including that discussed above, has depended on self report data, limiting the quality of conclusions that can be reached.

14.2 Measures

In order to objectively measure changes to skin conditions between pre- and postdeployment, the following photographs of participants who met the eligibility criteria for physical testing were taken at both pre- and post-deployment:

- Left and right cheek
- Back
- Left and right soles of their feet

Identities of individuals were masked by placing a template covering the participant's nose and eyes. In addition, all tattoos or other identifying marks were covered prior to the photograph being taken (see Appendix D).

Upon completion of both the pre- and post-deployment photography, de-identified photographs for each participant were assessed for changes in skin conditions by Dr Jennifer Menz (see Appendix D). It is important to note that the data Dr Menz received was de-identified and blinded in order to ensure that Dr Menz was not aware of which photographs were taken at pre- and which were taken at post-deployment.

14.2.1 Questions to be Addressed

The purpose of this chapter is to investigate the presence or absence of each of the following skin conditions:

- 1. Dermatitis
- 2. Psoriasis
- 3. Acne
- 4. Skin lesions (nevus, skin cancer, seborrheic warts, viral warts, hemangioma, pitted keratolysis)
- 5. Secondary skin rashes (tinea, sun damage, seborrheic dermatitis and rosacea)

14.2.2 Sample Sizes

Photographs were not provided for assessment until both the pre- and postdeployment photography had been completed. The total number of respondents who **completed both the pre- and post-deployment photography** was 115. In some instances, sample sizes varied as photographs were not included if they did not meet the required quality guidelines. Where sample sizes vary the sample size is noted within the text.

It is important to note that not all physical testing participants were invited to participate in the photography component of this study. In particular, photography was not offered to the final Mentoring Task Force unit due to concern with the time taken to complete this part of the physical testing data collection.

14.2.3 Data Analysis

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there may have been small differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences.
14.3 Results

The following section presents the findings for each skin condition measured in this study. Table 14.1, begins by presenting the percentage of participants who had evidence of a skin condition (excluding nevus, hemangioma and sun damage), at pre- and at post-deployment.

Table 14.1: Summary of skin conditions (excluding nevus, hemangioma and sun damage) at pre- and
post-deployment.	

Skin Condition		Post		Total
		Yes N(%)	No N(%)	
Due	Yes	41 (46.6%)	12 (13.6%)	53
Pre	No	2 (2.3%)	33 (37.5%)	35
Total		43	45	88

As can be seen from this table, 46.6% of participants had a skin condition, other than nevus, hemangioma and sun damage, at both pre- and post-deployment. The following results now consider each of the skin conditions measured in this study individually.

14.3.1 Dermatitis

As can be seen from Table 14.2 (Appendix U), there was no evidence of dermatitis in any of the respondents (n=107) at either pre- or post-deployment.

14.3.2 Psoriasis

As can be seen from Table 14.3 (Appendix U), there was no evidence of psoriasis in any of the respondents (n=108) at either pre- or post-deployment.

14.3.3 Acne

Of the total sample (n=104), 32.7% (n=34) had acne at both pre- and postdeployment, 3.8% of participants (n=4) developed acne between pre- and postdeployment, and 8.7% (n=9) of the sample were found to have acne at pre- but not post-deployment (Table 14.4, Appendix U).

14.3.4 Skin Lesions

Occurrence of skin lesions at pre- and/or post-deployment are presented in Tables 14.5 to 14.9 (Appendix U). As these tables show, there was no indication of either melanoma or non-melanomic skin cancer (n=82) or seborrheic warts (n=83) at either pre- or post-deployment.

Of the total sample (n=83) 1 participant had evidence of a hemangioma at pre- but not at post-deployment, and 1 participant had hemangioma at both pre- and post-deployment.

Of the total sample (n=89), 10.1% (n=9) of participants had evidence of pitted keratolysis at pre- but not at post-deployment, while 1 participant had pitted keratolysis at both pre- and post-deployment.

Of the total sample (n=88) 1 participant was found to have a viral wart at only predeployment, 1 participant had a viral wart at both pre- and post-deployment, and 1 participant was found to have a viral wart at post-deployment only, suggesting it could be associated with the most recent deployment.

14.3.5 Secondary Skin Rashes

The findings pertaining to secondary skin rashes at pre- and/or post-deployment are presented in Tables 14.10 to 14.13 (Appendix U). As these tables show, there was no indication of seborrheic dermatitis or rosacea in any of the sample (n=99 and n=100 respectively) at either pre- or post-deployment.

Of the total sample (n=88), 6.8% (n=6) had tinea at both pre- and post-deployment, and 9.1% (n=8) had tinea at pre-deployment only. There was no evidence of tinea at post-deployment only.

There was no evidence of sun damage in this sample (n=91) at post-deployment only. However, 29.7% (n=27) of participants showed signs of sun damage at both pre- and post-deployment, and there was evidence of sun damage for 1 participant at pre-deployment only.

14.4 Summary of Results

Table 14.14 summarises the key findings presented in this results section. Following the summary of results is a discussion section which draws together the findings presented above with reference to literature which has already been published.

Skin Condition	At Pre- Only	At Post- Only	At Both
Dermatitis	0.0%	0.0%	0.0%
Psoriasis	0.0%	0.0%	0.0%
Acne	8.7%	3.8%	32.7%
Skin Lesion – Skin Cancer	0.0%	0.0%	0.0%
Skin Lesion – Seborrheic Wart	0.0%	0.0%	0.0%
Skin Lesion – Viral Wart	1.1%	1.1%	1.2%
Skin Lesion – Hemangioma	1.2%	0.0%	1.2%
Skin Lesion – Pitted Keratolysis	10.1%	0.0%	1.1%
Skin Rash – Tinea	9.1%	0.0%	6.8%
Skin Rash – Sun Damage	1.1%	0.0%	29.7%
Skin Rash Seborrheic Dermatitis	0.0%	0.0%	0.0%
Skin Rash – Rosacea	0.0%	0.0%	0.0%

Table14.14: Summary of findings in this chapter

14.5 Discussion

Skin conditions, excluding the more common conditions such as nevi, hemangioma and solar damage were detected in 60.2% of the sample prior to deployment, and 48.9% at post-deployment. These findings demonstrate that almost all observed dermatological disorders were present at pre-deployment, with acne being the only notable emerging skin condition (3.8%) between pre- and post-deployment.

In addition, the prevalence of pitted keratolysis and tinea decreased between preand post-deployment. Pitted Keratolysis, a superficial infection of the outermost layer of the skin [26] and tinea are both common skin conditions which are aggravated by humid conditions [27]. One potential reason for the decrease in prevalence between pre- and post-deployment may therefore be the reduced humidity in Afghanistan. However, it is also possible that the decrease in the prevalence of these skin conditions may be due to an increased awareness and/or monitoring of skin conditions while on deployment.

Unlike previous studies involving military populations, there was, therefore, little evidence of newly acquired skin conditions associated with the most recent deployment, for those participants who completed the skin photography data collection at both pre- and post-deployment. Apart from acne, the only other exception to this was a single participant with a newly viral wart at post-deployment. Importantly, neither dermatological condition is considered to be a risk factor for long term morbidity.

These results have several implications. First, in the absence of the documented state of soldier's skin prior to deployment, it could appear that acne was a common outcome in the post-deployment environment. Given the observation that a range of somatic concerns emerge following deployment, it would be possible for these lesions to be wrongly attributed to some exposure on deployment, or being due to vaccinations. However the established presence prior to deployment, by the use of skin photography that allows comparisons, resolved these concerns. Second, it should be remembered that one of the associations that explains the rates of dermatological disorders in veterans is with psychiatric disorders. The relatively low prevalence of psychiatric disorder in this population, and the fact that only four months have elapsed post-deployment, suggests that the rates of dermatological disorders in line with emerging psychiatric morbidity. If this occurs, it again highlights that environmental exposures on deployment are not the critical cause.

A further observation of interest is that 94.8% of the sample had nevi, and 29.7% had sun damage at both pre- and post-deployment. While sun damage is of particular concern in the long term, there was no evidence to suggest that it increased as a result of the most recent deployment. The sun exposure on deployment, however, does require ongoing surveillance in those showing sun damage, for the emergence of squamous and basal cell cancers. Continued protection against sun damage while on deployment should, therefore, be encouraged for those with observable damage prior to deployment.

The findings from this study did not confirm observations of the Gulf War 1990-91 veterans suggesting an increase in dermatological conditions post-deployment. In particular, unlike the previous Gulf War studies, the MEAO Prospective Study did not find any evidence of seborrheic dermatitis [6]. One possible reason for these differences is the pre/post design of this study, which ensured that skin conditions existing immediately prior to deployment were identified.

14.6 Summary

In summary, dermatological conditions such as acne and tinea are common in ADF members. The limitation of this study is that the participants past history of skin disease was not recorded. Also at this stage, the medical records of participants were not examined to ascertain whether any skin conditions were treated during the deployment, with only residual evidence remaining at post-deployment. The absence of psoriasis and dermatitis raises the question as to whether the effectiveness of modern treatments, combined with the screening at enlistment, reduces the likelihood of these conditions in this population. However, dermatological management needs to remain a priority among soldiers because of its potential impact on capability.

The next chapter in this section focuses on **infectious diseases** (Chapter Fifteen). Once again, after providing a short introduction, the primary results are presented and discussed. The final chapter in this section provides the **Biochemistry** results (Chapter Sixteen).

Following sections of this report focus on other health outcomes of interest.

- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- Conclusions and Limitations are presented in Chapter Twenty Two

14.7 Further Analysis

As only prevalence rates are presented in this chapter, a full investigation of the associations between the presence skin conditions at pre- and/or post-deployment is required.

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Chapter Fifteen – Infectious Diseases

Key Points

- 1. Infection rates for participants who completed only the pre-deployment, as well as those who completed both the pre- and post-deployment blood tests were negligible:
 - There was no evidence that any of the participants had been infected with Leishmania.
 - There was no evidence that Australian veterans of the MEAO have been infected with Hepatitis C.
 - There was a very low rate of sero-prevalence for *Helicobacter pylori*.
 - Rates of sero-prevalence for other infectious diseases were unremarkable.
- 2. Deployment to the MEAO does not appear to materially affect the rate of sero-prevalence for the infectious diseases that this study measured.

This chapter presents and discusses the findings relating to infectious diseases including changes in the prevalence of Leishmania, Hepatitis C, *Helicobacter pylori*, Epstein-Barr virus, cytomegalovirus, Herpes Simplex Type 1, *Mycoplasma pneumonia* and *Chlamydia pneumonia*. The chapter begins by briefly discussing current literature pertaining to each of these infectious diseases. Primary results are then provided including a comparison of scores between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. The chapter concludes by discussing these findings regarding the prevalence of infectious diseases in this cohort.

15.1 Introduction

The following section provides an overview of each outcome of interest, including a short summary explaining the significance of each infectious disease, and any recently published data on prevalence rates. These particular measures were chosen for two reasons. First, they reflect the most commonly found infections within military populations, and second, because they are also considered relevant to post-deployment fatigue syndromes.

15.1.1 Leishmania

Leishmania is a parasite that causes a variety of clinical syndromes in humans, and which is endemic to many parts of the World, but is not found in Australia. In 1993, reports were published showing that some veterans of the Gulf War 1990-91 had developed Leishmaniasis as a result of deployment [1]. Subsequent studies have also shown that other forces deployed to the Middle East have significant rates of Leishmaniasis [2].

The protozoa that causes clinical Leishmaniasis is spread by sand-flies. As such, protective measures, such as the use of insect repellent, screening of sleeping quarters and covering exposed skin, can be effective in preventing the spread of the condition, and members of the ADF receive training in the use of these preventative measures. As Leishmania has not been found in Australia, it is presumed that the rate of sero-prevalence in military personnel before they deploy to areas such as the MEAO would be zero or close to zero.

15.1.2 Hepatitis C

Hepatitis C is a small single-stranded RNA virus, discovered in 1989 that is transmitted by the transfer of blood and tissue between individuals. It is associated with a progression to cirrhosis and end-stage liver failure in a significant proportion of those who become infected. It is the leading blood-borne infection in the US, and the most common cause of end-stage liver failure. It is estimated that 2% of the World's population is infected with Hepatitis C, representing 123 million people [3].

In Australia, the prevalence of Hepatitis C is low; approximately 1% of the population [4]. One of the factors that may contribute to this low prevalence is that all transplants and blood transfusions in Australia are tested for the presence of Hepatitis C prior to use. Therefore, nearly all new infections in Australia occur as a result of sharing of needles during illicit intravenous drug use.

To enter the ADF, applicants are required to answer questions relating to intravenous drug use. Applicants who indicate a history of intravenous drug use are generally not permitted to join the ADF. All members of the ADF are also screened for the presence of Hepatitis C on enlistment, and at regular intervals thereafter. Members of the ADF also receive regular education on the manner in which Hepatitis C is transmitted. Not surprisingly, the rate of infection in military populations in the US has been found to be low, although rates are higher among veterans [5]. For example, Hawkins et al. [6] reported the rate of infection among serving US Naval populations to be 0.4%.

15.1.3 Helicobacter pylori

Helicobacter pylori is a spiral gram-negative bacillus, with multiple flagella. Infection with Helicobacter pylori is an infection primarily of the human stomach, and results in a number of human diseases, mainly peptic ulcerative disease and malignancies of the stomach. In addition, it has been associated with a variety of other human diseases, such as atherosclerosis, although the role of Helicobacter pylori in these diseases is yet to be established [7].

The sero-prevalence of *H.pylori* infection in Australia has been studied in a number of different groups. Moujaber et al found an overall prevalence of 15.1%, using 2,413 sera from across Australia, gathered in 2002 [8]. Working from samples collected in 1991, they found an overall sero-prevalence of 38%, and a prevalence among those aged 20-30 of 18%. Robertson et al, working with blood donors from Victoria, found an overall sero-prevalence of 32% [9].

There is some evidence that military populations may be at increased risk of *H.pylori* infection [10]. For example, Smoak et al found a prevalence of 26.3% among US Army recruits [11]. Similarly, Furesz et al found a sero-prevalence of 23% among 2457 recruits into the Hungarian Army [12]. However, one study by Jackman et al [10] found that personnel on US nuclear submarines had a much lower sero-prevalence (9.4%). Of relevance to this study, Taylor et al studied the sero-positivity of American personnel before and after deployment in operation Desert Storm [13].

The initial infection rate for *H.pylori* was 37% with an annual sero-conversion rate while on deployment of 7.3%.

15.1.4 Epstein-Barr virus

Epstein-Barr virus, also known as EBV, is a member of the herpes family of viruses. In many countries, EBV infection occurs in childhood with near universal exposure, where it results in a transitory upper respiratory tract infection. In developed countries, childhood exposure is less universal, and exposure to EBV often does not occur until late adolescence or young adulthood. When subjects are first infected at this age, EBV can result in more serious illness, known as glandular fever or infectious mononucleosis. This clinical syndrome can be associated with a period of malaise and debility, which can last for many months. It seems that once a person has become infected, there is life-long infection without symptoms.

In the longer term, infection with EBV increases the risk of developing certain malignancies, such as the lymphomas. More recently, a particular type of gastric carcinoma has been associated with EBV infection [14]. There is also growing evidence that infection with EBV is a risk factor for the development of cardiovascular disease [15].

15.1.5 Cytomegalovirus

Cytomegalovirus is a member of the herpes virus group, and is a widespread infection with a world-wide distribution. The degree of sero-prevalence increases with age. Although cytomegalovirus can result in serious disease in humans (including birth defects), for most adults it results in a self-limiting clinical syndrome that lasts between two and six weeks, and is characterised by malaise and lethargy. Once infected, humans are believed to be infected for life, although it is not clear in which tissue the latent infection resides. Prior infection with herpes family viruses such as cytomegalovirus is associated with cognitive impairment and an increased risk of psychiatric disorders such as schizophrenia [16, 17].

The seroprevalence of cytomegalovirus in Australia was identified in a national survey of 3,593 samples of serum [18]. This study identified that the percentage of the population with a positive cytomegalovirus increased with age (Table 15.1).

Age group (yr)	No. of samples	% Positive	CI (95% ± 5%)
1-2	251	38.2	32.2-44.3
3-4	331	39.1	34.0-44.5
5-9	330	38.8	33.5-44.3
10-14	369	43.6	38.5-48.8
15-19	387	49.9	44.7-54.9
20-24	384	53.6	48.5-58.7
25-29	384	47.1	42.0-52.3
30-34	192	53.6	46.3-60.8
35-39	194	69.1	62.0-75.5
40-44	192	71.8	64.9-78.1
45-49	194	68.0	61.7-75.2
50-54	193	74.1	67.3-80.1
55-59	192	79.2	72.7-84.7

Table 15.1: Cytomegalovirus seroprevalence in Australia by age group

A study of veterans of the Gulf War 1990-91, showed a 48.8% past infection rate among those with multi-symptom disease, while 51.6% with this condition had serological evidence of prior infection [19]. There do not appear to be any other studies that have examined the sero-prevalence of cytomegalovirus in military populations.

15.1.6 Herpes Simplex Type 1

Herpes Simplex, which results in cold sores, is a very common infection in humans, with a world-wide distribution. As with other members of the herpes virus group, once infection has occurred, there remains a life-long infection of the individual. For Herpes Simplex, the residual infection resides within the central nervous system, manifesting itself as skin lesions at times when the body is suffering from some other insult to the immune system, such a systemic virus (hence the name, 'cold sores'). As with other members of the herpes virus family, there is evidence that the long-term infection with this virus is associated with increased cardiovascular mortality, cognitive impairment and some psychiatric disorders [16, 17].

The sero-prevalence of Herpes Simplex has been established in Australia, by use of a large study of 11,000 Australian adults [20]. This study established that the sero-prevalence was 76%, with increasing prevalence with increasing age. As this study's subjects are drawn from the Australian population, it can reasonably be expected that they will show high rates of being sero-positive. This study appears to the first to examine sero-prevalence for Herpes Simplex in a military population.

15.1.7 Mycoplasma pneumoniae

M. pneumoniae is a very small bacterium that is devoid of a cell wall, and is primarily associated with influenza-like illness that progresses to an atypical pneumonia, but which is usually self-limiting. Military populations, particularly those on board military ships, where there can be close crowding of populations, are particularly at risk for outbreaks of *M. pneumoniae*. For example, Sliman et al [21] recently documented 179 cases of respiratory infection on board a US Naval ship, which were due to an outbreak of *M. pneumoniae*. In another example, Ekman et al [22] described an epidemic of respiratory tract infections in a Finnish recruit training camp. However, while there are multiple descriptions of epidemics in military populations, there do not appear to be many systematic studies of the prevalence of this infection in military populations.

15.1.8 *Chlamydia* (Chlamydophila) *Pneumoniae*

This is a small bacterium that causes respiratory infections in humans. However, it has also been associated with the development of a wide range of other diseases, including Alzheimer's disease, pre-eclampsia and lung cancer, and more recently it has been associated with asthma [23]. It has also been shown to be correlated with ischemic heart disease. For example, Mono et al showed that antigenic evidence of infection with *C. pneumoniae* was more common in cases of coronary disease than in controls [24].

Studies have shown that serological evidence of past *C. pneumoniae* infection is relatively common. For example, Ben-Yaakov et al found that 74% of Israeli adults had evidence of previous infection with *C. pneumoniae* [25]. Furthermore, a study in Japan found that the rate of serology for *C. pneumoniae* varied from year to year, ranging from 73.3% to 59.0%. More recently, there has also been some evidence that infection with *C. pneumoniae* can be associated with obesity [26].

15.2 Measures

Antibodies come in different classes; in this case, the most relevant classes are IgM and IgG. Elevation of IgG indicates an infection in the past; this may be as long as decades in the past. IgG does slowly decline, and may eventually revert to normal levels.

In this study, we investigated the prevalence of certain infectious diseases by indirect methods – that is, we measured the presence or absence of IgG antibodies, the body's reaction to infection with the infective agent. This does not necessarily indicate current infection, but it can indicate if the individual has *ever* been infected with that infectious agent.

15.2.1 Questions to be Addressed

Primarily, the purpose of this chapter is to investigate the presence or absence of IgG antibodies for each of the following infectious diseases:

- 1. Leishmaniasis
- 2. Hepatitis C
- 3. Helicobacter pylori
- 4. Epstein-Barr Virus
- 5. Cytomegalovirus
- 6. Herpes Simplex Type1
- 7. Mycoplasma pneumoniae
- 8. Chlamydia pneumoniae

15.2.2 Sample Sizes

The total number of respondents who **completed a blood test at both pre- and post-deployment** was 348. Of the 399 participants who completed both the pre- and post-deployment physical test, 8 participants refused a blood test at pre-deployment, 1 sample was haemolysed, 23 refused a blood test at post-deployment and 19 refused a blood test at both pre- and post-deployment.

The total number of respondents who **only completed a blood test at predeployment** was 228. Of the 256 participants who only completed a pre-deployment physical test, 28 participants refused a pre-deployment blood test.

In some cases, such as the phlebotomist being unable to draw sufficient blood, or the sample being haemolysed due to high temperatures at the physical testing site, there were small variations in the sample size for each outcome of interest. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

15.2.3 Data Analysis

The following section presents the findings for each infectious disease measured in this study. For each infectious disease of interest, a comparison of pre-deployment data for those respondents who only completed the pre-deployment blood tests, and those who completed the pre- and post-deployment blood tests is presented. In addition, a paired t-test was used to analyse the change between pre- and post-deployment for each measure.

While there were differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences.

15.3 Results

The following section presents the findings for each infectious disease measured in this study. For each infectious disease of interest, a comparison of pre-deployment data for those respondents who only completed the pre-deployment blood tests, and those who completed the pre- and post-deployment blood tests is presented. In addition, an analysis of the change between pre- and post-deployment measures is provided, noting any statistical significance. Finally, analyses of associations between changes in rates of infectious diseases between pre- and post-deployment and other variables of interest are presented.

15.3.1 Leishmaniasis

Table 15.2 (Appendix V) compares the rates of leishmaniasis infection at predeployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.3 (Appendix V) presents the change in rates of Leishmaniasis infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As can be seen from tables 15.2 and 15.3 (Appendix V), respondents did not have evidence of a Leishmaniasis infection at either pre- or post-deployment.

15.3.2 Hepatitis C

Table 15.4 (Appendix V) compares the rates of Hepatitis C infection at predeployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.5 (Appendix V) presents the change in rates of Hepatitis C infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As can be seen from tables 15.4 and 15.5 (Appendix V), respondents did not show any evidence of Hepatitis C infection at either pre- or post-deployment.

15.3.3 Helicobacter pylori

Table 15.6 (Appendix V) compares the rates of H.pylori infection at pre-deployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.7 (Appendix V) presents the change in rates of H.pylori infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As can be seen from Table 15.7 (Appendix V), of the those respondents who provided both a pre- and post-deployment blood sample, 13.6% showed serological evidence of any H.pylori infection. A very small number lost serological evidence of infection during the deployment, and a similar and small number gained serological evidence of infection while on deployment.

15.3.4 Epstein-Barr virus

Table 15.8 (Appendix V) compares the rates of Epstein-Barr virus infection at predeployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.9 (Appendix V) presents the change in rates of Epstein-Barr virus infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As presented in Table 15.9 (Appendix V), almost 90% of the cohort showed serological evidence of infection with Epstein-Barr virus. There was also some evidence of a small amount of seroconversion occurring on deployment.

15.3.5 Cytomegalovirus

Table 15.10 (Appendix V) compares the rates of cytomegalovirus infection at predeployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.11 (Appendix V) presents the change in rates of cytomegalovirus infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As presented in Table 15.11 (Appendix V), 48% of participants had serological evidence of infection with cytomegalovirus.

15.3.6 Herpes Simplex Type 1

Table 15.12 (Appendix V) compares the rates of herpes simplex infection at predeployment between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.13 (Appendix V) presents the change in rates of herpes simplex infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As presented in Table 15.13 (Appendix V), a total of 45.4% of the cohort displayed some evidence of infection with herpes simplex virus, prior to , after , or at both pre- and post-deployment. Unexpectedly, 7.5% of the cohort was sero-positive prior to deployment, but seronegative after returning from the MEAO.

15.3.7 Mycoplasma Pneumoniae

Table 15.14 (Appendix V) compares the rates of *M. pneumoniae* infection at predeployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.15 (Appendix V) presents the change rates of *M. pneumoniae* infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. As presented in Table 15.15 (Appendix V), 19.9% of the pre- and post-deployment sample had evidence of an infection with *M. pneumoniae*. Of this cohort, 8.6% sero-converted while on deployment, indicating that they had been exposed to *M. pneumoniae* during the deployment. Another 12.2% changed from being sero-positive to being seronegative; for these people, the history of their pre-deployment infection had faded to the point that their serological evidence fell below the level regarded as positive.

15.3.8 Chlamydia (Chamydophila) Pneumoniae

Table 15.6 (Appendix V) compares the rates of *C. pneumoniae* infection at predeployment, between those who only completed the pre-deployment blood sample and those who completed both the pre- and post-deployment blood sample. In addition, Table 15.7 (Appendix V) presents the change in rates of *C. pneumoniae* infection between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. The rate of sero-positivity for *C. pneumoniae* was 68.4%, with evidence of exposure and infection occurring among a small percentage of those who were deployed to the MEAO (4.3%).

15.4 Discussion

This chapter analysed the past history of infection with Leishmaniasis, Hepatitis C, *Helicobacter pylori*, Epstein-Barr virus, cytomegalovirus, Herpes Simplex Type 1, *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* by measuring IgG antibodies. For both respondents who only provided a blood sample at pre-deployment, and respondents who provided a blood sample at both pre- and post-deployment, the rates of infection were found to be similar to or less than rates of infection in the

general Australian population. The one exception to this was for *Mycoplasma pneumoniae*. In this instance, there was a high level of positive serology for at both pre- and post-deployment.

In particular, there was no evidence that respondents had been infected with Leishmaniasis. This is consistent with anecdotal evidence, in that there have been no reported examples of Australian personnel developing clinical syndromes that would be consistent with Leishmaniasis infection. However, this result is in contrast to the published data concerning other groups deployed to MEAO, which do show evidence of infection with Leishmaniasis [2, 27, 28]. There could be several reasons why this is the case. It is possible that the areas where the majority of Australian personnel are deployed are not areas that are endemic for Leishmaniasis. It may also be that the preventative measures used by the ADF are effective in preventing infection with Leishmaniasis.

Findings also identified a zero rate of infection with Hepatitis C. It should be remembered that this is a population screened for Hepatitis C on enlistment. In addition, they receive education on Hepatitis C transmission, and are regularly screened for Hepatitis C and evidence of illicit drug use. All of these factors could contribute to the absence of Hepatitis C infection.

This study also found a particularly low rate of *H. pylori* infection. This is an important finding as it is one of the lowest reported rates within the published literature. There are a number of possible reasons for the low rate of sero-prevalence. First, there may be a selection effect, in that people enlisting in the ADF are specifically screened for evidence of peptic ulcerative disease, and those with evidence of active peptic ulcerative disease are not able to enlist. This is likely to mean that the ADF as a whole have lower rates of *H. pylori*. It may also be the case that this low rate reflects the declining rates of *H. pylori* infection throughout the developed world- although as yet the specific reason for the decline is still being debated. Therefore, findings from this study may reflect a more general trend. However, it should also be noted that this is a relatively young population and *H. pylori* infection is known to increase with age. The dominant profile of this cohort may therefore, contribute to the particularly low rate of serological evidence of *H. pylori* infection at both pre- and post-deployment.

A descriptive analysis of Epstein-Barr virus sero-positivity suggests that there may have been a small association with deployment. However, it is possible that much of the newly acquired infection was at a sub-clinical level, though it is also possible that it may have given rise to cases of clinical infectious mononucleosis. Indeed, a small number of cases also showed elevated IgM (not reported in the results), and further tests to diagnose infectious mononucleosis were performed. Overall, however, rates of serological evidence of past infection with Epstein-Barr virus appear to be consistent with the reported rates within the general population [29, 30].

Finally, the rate of sero-positivity to cytomegalovirus and Herpes Simplex Type 1 were broadly consistent with rates reported for the Australian population and did not significantly alter between pre- and post-deployment. However, it should be noted that this chapter does not explore the association between the presence of these herpes family of viruses and post-deployment somatic or psychological symptoms, nor does it investigate the relationship between herpes viruses and cognitive functioning.

15.4.1 Declining Sero-Positive Rates Between Pre- and Post-Deployment

Even more puzzling is that except for Leishmaniasis and Hepatitis C which had a zero sero-prevalence at both pre- and post-deployment, prevalence rates *declined* between pre- and post-deployment. For example, there was a group of 7.5% who were sero-positive for Herpes Simplex Type 1 prior to deployment, but sero-negative after deployment.

This result is both puzzling and counter intuitive. Many studies have found an association between increasing manifestations of infection with herpes simplex and psychological stress. For example, a study by Faulkner and Smith showed an increase in psychological stress was associated with a higher rate of cold-sores [31]. Thus, it would be reasonable to have expected that the rate of sero-positivity would have increased during deployment, rather than declined.

One possibility for the reduction in sero-prevalence at post-deployment is that the IgG for these types of infections returns to normal much more quickly than was originally thought. In developed countries such as Australia, people are often exposed to repeated exposures which often cause sub-clinical infection resulting in an elevated IgG. When exposure ceases, such as in the case of these participants who were deployed to group of young Aussies off to patrol the remote regions of Afghanistan, and are away from large crowds for significant amounts of time, exposure ceases and their levels return to normal. However, further investigation of this unusual finding is beyond the scope of this report.

15.4.2 Consequences of Long-Term Infection

While the prevalence of these infections is no higher than in the general population, they may still have an effect on the long term health of deploying personnel which could result in a cognitive functioning and psychological morbidity [16, 17]. This is especially the case when combined with other longer term risk factors such as the increased exposure to traumatic deployment exposures which also lead to changes in cognitive function. The interaction between deployment exposures and the presence of the herpes family of viruses requires further consideration as the significance of these infections not be felt so much in the short term health of deploying personnel but that they further add to the risk of future morbidity and/or mortality. The chapter pertaining to allostatic load (Chapter Twenty One) will discuss this in more detail.

15.5 Summary

For participants who only completed a pre-deployment blood test and for participants who completed both the pre- and post-deployment blood test, the rates of infection were similar or less than, the rates of infection in the general Australian population and did not appear to be dramatically affected by deployment to the MEAO. In particular, it was positive to note that unlike our coalition partners, there was no evidence for leishmaniasis or hepatitis C in this sample. The one exception to these low infection rates across the board was for mycoplasma pnuemoniae which had a high level of positive serology at both pre- and post-deployment.

One of the most interesting findings to come out of this chapter however, was the declining sero-positive rates between pre- and post-deployment for IgG titre measures of the Herpes family of viruses. These findings are difficult to explain but

one possibility is that they may relate to the impact of stress on the immunocompetence. However, this particular finding requires more investigation.

The final chapter in Section Three focuses on biochemical and chemical measures. Once again, after providing a short introduction, an explanation of the primary measures is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature.

Following sections of this report focus on other health outcomes of interest.

- Social Health in Section Four
- Identifying Possible Risk Markers in Section Five
- **Conclusions and Limitations** are presented in Chapter Twenty Two

15.6 Further Analysis

As only prevalence rates are reported in this chapter, a full investigation of the associations between the presence of infectious diseases at pre- and/or post-deployment is required. In addition, the decrease in sero-prevalence rates for the herpes family of virus requires further exploration.

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Chapter Sixteen – Biochemistry

Key Points

- 1. The **majority of participants in this study were healthy** based on the biochemical and chemical test results reported in this chapter.
- 2. In particular, findings reported in this chapter demonstrate that:
 - lead levels prior to deployment were well below the hazardous level,
 - there was no evidence of diabetes mellitus; and
 - measures of renal and liver function, pancreatic enzymes and serum lipids reflected a primarily healthy population.
- 3. There was an elevation in creatine kinase among a small number of this cohort, which may reflect involvement in contact sport or arduous physical training prior to testing, which was not of clinical significance.

This chapter presents findings related to changes in biochemical and chemical health. In particular, the chapters focus on changes to measures related measures of creatine kinase, glucose metabolism, renal function, hepatic function, pancreatic enzymes and serum lipids associated with cardiovascular risk. The chapter begins by briefly discussing current literature pertaining to each of these biochemical and chemical measures. Primary results are then provided including a comparison of outcomes between participants who completed only the pre-deployment, and those who completed both the pre-and post-deployment measure. The chapter concludes by discussing the findings pertaining to biochemical and chemical health. Findings pertinent to the focus of this chapter are also presented in Chapter Twenty One (Allostatic Load).

16.1 Introduction

The following section provides an overview of each outcome of interest, including a short summary explaining the significance of each type of measure used.

16.1.1 Serum Lead

As lead is a dense metal that it is widely used in the production of amongst other things, bullets. However, lead is also a metal that is toxic, resulting in cognitive impairment, neurological effects, renal impairment and anaemia. This has led to the development of regulations concerning occupational and non-occupational exposure in Australia [1]. A number of studies have shown that people who work in indoor firing ranges can, over time, develop clinically significant lead deposits within their bodies, which is reflected in an elevated serum lead measurement. For example, a study by Vlawy et al [2] involving law enforcement trainees, showed that over a three month period they had developed elevated serum lead levels while training in an indoor firing range. Similar concerns have been raised about the possible elevated serum lead among members of the ADF who have intense training regimes

16.1.2 Measures of Glucose Metabolism

In this study, two different measures of glucose metabolism, random serum glucose and HbA1c, were obtained at both pre- and post-deployment. Random serum

glucose is not a particularly accurate measure of glucose metabolism, as it is affected by events that immediately preceded the drawing of the venous sample, such as the consumption of a large meal. Of much greater accuracy and utility is HbA1c as this documents a much longer window of observation of glucose metabolism. This is a measure of glycated haemoglobin, which reflects the level of serum glucose over the past few months, and is now being increasingly accepted as a more accurate diagnostic tool for the presence of diabetes mellitus [3].

16.1.3 Creatine Kinase

Creatine kinase is an enzyme associated with energy metabolism, and it is released into the serum from those tissues that have a need for high levels of energy, such as the heart, skeletal muscle and the brain. In certain diseases where there is damage to these tissues, creatine kinase is released in much higher levels. Several studies have shown that extreme physical exertion, and contact sports such as football can result in an elevation of creatine kinase. For example, Lilleng et al reported on a series of cases who had developed elevation of creatine kinase after working out in a gymnasium, and receiving physiotherapy [4].

16.1.4 Measures of Renal Function

Three important measures of renal function were examined in this study. The first is the blood urea level. Urea is a toxic by-product of metabolism, and an important function of the kidney is to excrete urea. In renal disease, the level of urea will rise, but elevations in urea can also be caused by other conditions, such as excessive protein metabolism and dehydration particularly after strenuous exercise.

A second measure of renal function captured in this study was serum creatinine. This tends to be more indicative of renal disease, although there are also other diseases that can cause an elevation in serum creatinine. A final measure of renal function is the eGFR. This is a derived measure of renal function, calculated by combining several different measures. It is an electronic calculation of the Glomerular Filtration Rate. While it is a sensitive measure of renal function, eGFR can also be altered by other pathological and physiological conditions.

It is important to note that all members of the ADF are screened for renal disease on enlistment. This screening is conducted by a clinical interview, examination, and also involves the testing of urine for the presence of sugar, protein and blood by a dipstick. Although these measures would be unlikely to detect all renal disease, particularly in early stages, they would identify those participants with established renal disease.

16.1.5 Measures of Liver Function

The liver has a broad range of complicated functions within the human body and liver function can be assessed by measuring a range of biochemical patterns in serum. Liver enzymes are released when hepatic cells are injured or damaged (alanine transaminase, lactate dehydrogenase, aspartate transaminase, gamma glutamyl transferase and alkaline phosphatise). In other cases, there are measures of products such as bilirubin, which should be metabolised by a healthy, well functioning liver. Collectively, all of these measures are known as "the liver function tests" which were included within the range of tests collected at both pre- and post-deployment in this study. On enlistment, all members of the ADF are also examined for clinical signs of liver disease. However, such an examination is likely to only identify significant impairment of liver function.

16.1.6 Measures of Pancreatic Enzymes

The pancreas secretes a number of enzymes into the digestive tract to facilitate the digestion and absorption of food, and small amounts of these enzymes can be detected in human serum. The two most common of these enzymes are lipase and amylase which were both measured in this study at pre- and post-deployment. When the pancreas suffers injury or disease, the level of these enzymes rises. There are however, a wide range of conditions that can cause elevation of lipase, amylase or of both [5].

16.1.7 Measures of Serum Lipids

Measures of serum lipids are important predictors of cardiovascular risk. They are important because they can be altered, by means such as dietary modification and medication, thereby reducing or increasing the individual's risk of cardiovascular disease. In addition to measuring total cholesterol, this study also measured sub-types of lipoproteins (low density lipoprotein, high-density lipoprotein, and triglycerides). In some cases, higher levels of some types of lipoprotein are associated with lower cardiovascular risk, while other sub-types are associated with higher cardiovascular risk. The resulting overall pattern is usually referred to as a "lipid profile".

Members of the ADF who are recruited over the age of 35, and in certain occupations, such as military pilots, are screened for poor lipid profiles on enlistment as a matter of course. In some cases, enlistment will be refused if the lipid profile suggests a significant risk of cardiovascular disease. Members of the ADF are also regularly screened for their lipid profile, and dietary advice and lipid-lowering medication is provided for those members of the ADF that have a poor lipid profile.

Levels of serum lipids have been studied in various populations. As an example, the Australian Institute of Health and Welfare report [6] found that Australian men had a mean cholesterol of 5.5 mmol/l, and that among men aged 25-34, just over thirty per cent have an elevated serum cholesterol. Saely et al measured the levels of serum cholesterol in a Swiss military conscripts, and found mean cholesterol of 4.1 mmol/L [7]. This group was younger than the MEAO Prospective Study cohort, and unlike the Australian Defence Force were conscripted. Both factors may have an effect on cholesterol levels, as it is apparent that the Swiss authorities enlist all of those who are conscripted, irrespective of issues such as a BMI outside of the normal range.

16.2 Measures

Estimations were made of the level of the biochemical or chemical measure using standardised and approved protocols for undertaking these measurements (Appendix G). To avoid inter-laboratory variation, each assay was processed in the same pre-specified laboratory at pre- and post-deployment. However, this did mean that some samples had to be transported very long distances, and there was some evidence that a small number of samples (n=9) may have haemolysed during this trip. These samples were excluded from the study.

16.2.1 Sample Sizes

The total number of respondents who **completed a blood test at both pre- and post-deployment** was 348. Of the 399 participants who completed both the pre- and post-deployment physical test, 8 participants refused a blood test at pre-deployment, 1 sample was haemolysed, 23 refused a blood test at post-deployment and 19 refused a blood test at both pre- and post-deployment.

The total number of respondents who **only completed a blood test at predeployment** was 228. Of the 256 participants who only completed a pre-deployment physical test, 28 participants refused a pre-deployment blood test.

In some cases, such as the phlebotomist being unable to draw sufficient blood, or the sample being haemolysed due to high temperatures at the physical testing site, there were small variations in the sample size for each outcome of interest. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

16.2.2 Data Analysis

The following section presents the findings for each biochemical measure measured in this study. For each biochemical measure of interest, a comparison of predeployment data for those respondents who only completed the pre-deployment blood tests, and those who completed the pre- and post-deployment blood tests is presented. In addition, a paired t-test was used to analyse the change between preand post-deployment for each measure. The exception to this is serum lead, where only a pre-deployment measure was conducted.

While there were differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences.

16.3 Results

16.3.1 Serum Lead

Table 16.1 (Appendix W) shows the level of serum lead in participants prior to deployment (n=599). As no post-deployment measures were collected (refer Chapter Three, Table 3.6), comparison between pre- and post-deployment are not shown. The results show that all subjects had levels within the normal range at pre-deployment.

16.3.2 Glucose Metabolism

There were no significant differences in the pre-deployment Hb1Ac and random blood glucose results of participants who only completed the pre-deployment blood sample, compared to those who completed both the pre- and post-deployment blood sample (Tables 16.2 and 16.3 Appendix W)

As can be seen in Tables 16.4 and 16.5 (Appendix W), all respondents who completed the pre- and post-deployment physical tests fell within the normal range for Hb1Ac at both pre- and post-deployment. While there were a few minor elevations in the results for the random blood glucose, in view of the normal levels of Hb1Ac, these are very likely to be due to factors such as the consumption of a recent large meal, rather than indicative of any underlying diabetic condition.

16.3.3 Creatine Kinase

The mean creatine kinase score was significantly lower (p=0.0012) for respondents who only completed the pre-deployment blood test compared to those who responded at both pre- and post-deployment (Table 16.6, Appendix W).

As can be seen from Table 16.7 (Appendix W), 36.8% of participants who completed both the pre- and post-deployment physical test increased at least one category, while over the same period 23.3% decreased at least one category.

16.3.4 Renal Function

A comparison of the results from the blood test for urea, creatinine and eGFR at predeployment, between respondents who only completed a pre-deployment, and those that completed both the pre- and post-deployment blood test, showed no significant differences Table 16.8, 16.9 and 16.10 (Appendix W).

Results for urea showed that 75.3% of the pre- and post-deployment sample were normal at both pre- and post-deployment, 6.0% had a high urea level only at pre-deployment, 12.9% had a high urea level only at post-deployment, and 5.8% of respondents fell into the high category at both pre- and post-deployment (Table 16.11, Appendix W).

Results for creatinine showed that 87.3% of the pre- and post-deployment sample were normal at both pre- and post-deployment, 2.9% had a high creatinine level only at pre-deployment, 7.8% had a high urea level only at post-deployment, and 2.0% of respondents fell into the high category at both pre- and post-deployment (Table 16.12, Appendix W).

Results (Table 16.13 and 16.14, Appendix W) indicate that respondents were free from kidney disease and severely impaired eGFR at both pre- and post-deployment. However, a small number of respondents had moderate impairment at pre- (0.9%) and post-deployment (1.2%), and a much larger percentage had mild impairment at pre- (47.1%) and post-deployment (58.9%).

16.3.5 Liver Function Tests

Analyses of all of the pre-deployment liver function tests (alanine transaminase, lactate dehydrogenase, aspartate transaminase, gamma glutamyl transferase, alkaline phosphatise and bilirubin) comparing results from respondents who only completed a pre-deployment with results from those who completed both the preand post-deployment blood test, found only one significant difference: for aspartate transaminase (p=0.05) (Tables 16.15 to 16.20, Appendix W).

In addition, Tables 16.21 to 16.26 (Appendix W) present the change in results between pre- and post-deployment, for the respondents who provided a blood test at both pre- and post-deployment. These show that the majority of respondents fell within the normal ranges for all tests at both pre- and post-deployment.

16.3.6 Pancreatic Enzymes

There were no significant differences in the pre-deployment amylase and lipase results between participants who only completed the pre-deployment blood sample, compared to those who completed both the pre- and post-deployment blood sample (Tables 16.27 and 16.28, Appendix W)

In addition, Table 16.29 and 16.30 (Appendix W) present the change amylase and lipase levels between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. Less than 1% had an elevated amylase, and 1.7% had an elevated lipase at either pre- or post-deployment.

16.3.7 Lipid Profile

Analyses of the all of the pre-deployment lipid profile tests (total cholesterol, low density lipoprotein, high-density lipoprotein and triglycerides), comparing results from respondents who only completed a pre-deployment with results from those who completed both the pre- and post-deployment blood test, found only one significant difference: for low density lipoprotein (p=0.032) (Tables 16.31 to 16.34, Appendix W).

In addition, Tables 16.35 to 16.38 (Appendix W) present the change in lipid results between pre- and post-deployment, for the respondents who provided a blood sample at both pre- and post-deployment. Prior to deployment, 8.9% of the sample had elevated serum cholesterol. At post-deployment 12.4% of the sample had elevated serum cholesterol.

16.4 Discussion

Once again the majority of participants were found to be healthy based on the biochemical and chemical tests undertaken in this study. This was the case not only prior to, but also upon return from their most recent deployment.

All participants who completed a blood test prior to deploying had a serum lead level well below the hazardous level. In addition, the levels found were very similar to the general population [8, 9], a finding that strongly indicates that the intensive training undertaken by some units prior to deployment is not a risk factor for lead toxicity.

The levels of HbA1c found in this study were also well below the level that suggests the existence of diabetes mellitus. This finding was, however, not unexpected, as ADF members are screened for the existence of diabetes mellitus prior to recruitment, with positive indications of diabetes leading to exclusion. Furthermore, those with risk factors for the future development of diabetes, such as excessive weight, are also excluded. In addition, this is a cohort that has incentives and programs aimed at maintaining physical fitness. The few elevated random serum glucose levels that were found in this study are very likely to be due to factors such as the consumption of a high glucose containing food substance in the hours prior to testing, however this may indicate some risk of future dysregulation of glucose metabolism in these individuals. There was no evidence that the most recent deployment to the MEAO had any material effect on measures of diabetic health.

There was, however, a surprising elevation in levels of creatine kinase for a small number of participants in this study. This was highly likely to be explained by an elevation that occurs after extreme physical exercise, which physical training often involves, or due to the participation in contact sports. Both of these activities are documented in the literature to result in elevations of creatine kinase [10, 11]. The elevations in creatine kinase were equally prevalent at pre- and post-deployment, suggesting that the most recent MEAO deployment was not a factor in the increase in measures of creatine kinase. This type of elevation in creatine kinase has also been reported in other military populations. For example, Aizawa et al [12] reported on levels of creatine kinase in 19 soldiers before and after a series of marches carrying 45 kilograms of kit. They found that CK rose from a mean of 356.9 U/I prior to undertaking the march to a level of 633.8 U/I directly afterwards. In a much larger study undertaken in the US, Kenny et al [13] studied the creatine kinase levels in a group of 499 recruits undergoing basic training. They found that creatine kinase levels increased during the early days of initial training, to a mean of 1,226 U/I on day seven of training, with one recruit recording a level of 35, 056 IU/I. Thus, our finding of elevated levels of creatine kinase in military populations is consistent with the findings of other studies.

Overall, the levels of the measure of renal function reflected a healthy population. There was, however an increase in the levels of eGFR abnormality at postdeployment. Yet it should be noted that the increases were small, and were not suggestive of underlying significant renal disease at either pre- or post-deployment. Nevertheless, it was noteworthy that just over sixty percent of the participants had mild or moderate evidence of impairment. This finding requires further investigation. The deployments in Afghanistan are in a very hot and high altitude environment that may have led to dehydration and impacted on renal functioning post-deployment. Working in the Framingham study, Culleton et al [14] have shown that even mild levels of renal impairment increase risk for all cause mortality many years later. It would therefore be interesting to follow this cohort over time and see if a similar pattern emerges in the future - with mild and moderate impairments of eGRF possibly progressing to clinically significant renal disease.

There were some members of the cohort who also displayed some abnormal liver function tests, both prior to deployment, as well as following the most recent deployment. The abnormalities that were apparent, however, were not large. Liver enzymes are also markers of oxidative stress and hence these changes warrant further examination. It is possible that occasional cases of, for example, elevated bilirubin may relate to undiagnosed cases of Gilbert's Syndrome, which affects between six and ten percent of the population [15]. In turn, Gilbert's Syndrome has been associated with a decrease in atherosclerosis [16].

Other elevations, such as the occasional high levels of gamma glutamyl transferase, may reflect a recent heavy use of alcohol, or non-steroidal anti-inflammatory drugs, such paracetamol or naproxen. Gamma glutamyl transferase can be used as a screen for public health interventions to decrease high levels of alcohol usage. The relationship between these changes and the alcohol usage in this population warrants further examination. Raised levels may also be due to undiagnosed steatosis (fatty liver), which Pratt and Kaplan [17], in their major review of abnormal liver function tests in asymptomatic individuals, found to be the major agents responsible for elevated hepatic enzymes. Two other agents which are common causes of elevated liver function tests in the general population, Hepatitis B and Hepatitis C, can be excluded in this population; because of universal vaccination in the case of Hepatitis B; and in the case of Hepatitis C, serological evidence reported elsewhere in this study (see Chapter Fifteen) of a zero rate of infection with this virus.

There were a very small number of participants who had elevation in lipase or in amylase. These elevations were not large, and they did not increase at post-deployment testing. Some of these elevations would be a reflection of the normal distribution. Normal ranges are calculated by a number of standard deviations away from the mean, so that in any normal population a small number will fall just out of the normal range. In addition, there are a number of conditions, ranging from alcohol-induced pancreatitis, to blunt trauma to the abdomen, which can cause these elevations.

This study's finding of lower serum cholesterol in the military population when compared to the civilian population is consistent with a study of Royal Australian Air Force personnel compared to an age-matched civilian population [18]. This very good lipid health is likely to translate into long-term lower rates of cardiovascular disease. However, the increases in cholesterol following deployment warrants further consideration as lipid metabolism is associated with PTSD [19].

16.5 Summary

Once again this study has demonstrated that based on the biochemical and chemical measures tested in this study, the sample was primarily health. Despite some previous concerns, lead levels prior to deployment were well below a hazardous level. Results also suggest that the vast majority of participants had normal liver and

renal function, and that there was no evidence of diabetes mellitus. There was, however, a surprising elevation in levels of creatine kinase for a small number of participants either at pre- or post-deployment. However, this is likely to be due to physical exercise that many participated in just prior to testing.

The next section pertains to the **social health** of this sample, with the first chapter focusing on **personal relationships** (Chapter Seventeen). Once again, after providing a short introduction, an explanation of the primary measures is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature.

Following sections of this report focus on other health outcomes of interest.

- Identifying Possible Risk Markers in Section Five
- **Conclusions and Limitations** are presented in Chapter Twenty Two

16.6 Other Chapters of Relevance

• Chapter Twenty One – Allostatic Load

16.7 Further Analysis

As only prevalence rates are reported in this chapter, a full investigation of the associations between abnormal biochemistry results at pre- and/or post-deployment is required.

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Section Four - Introduction to Social Health

This section focuses on the social health of deploying personnel who participated in the MEAO Prospective Study. The World Health Organisation defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [1, p. 1]. Up until now, however, social well-being or social health has only been considered as a potential risk or protective factor for physical and/or mental health outcomes. In this capacity, social health research has confined itself to concepts such as social support, social isolation, social capital and even the social determinants of health. Researchers have neglected social health as an outcome in its own right.

One potential reason that social health has been neglected is that, despite numerous references to it by the World Health Organization documents and the health literature, there is no universally accepted formal definition of social health. A common understanding is that it refers to "the quality of an individual's network of professional and personal relationships" [2, p. 549]. One of the more complete definitions covers all levels of social functioning including interpersonal, family, workplace, community and society [3]. When discussing social health, researchers have also included how people connect and communicate with each other, their roles within various small and larger groups, and subsequent social activities [4].

For military populations, professional relationships are particularly important, encompassing such things as unit cohesion, friendships with military colleagues [5] and leadership [6]. However, relationships with partners, children, extended families and communities also make a considerable contribution to military members social health and general wellbeing [7].

The following chapters in this section focus on the physical health outcomes of interest.

- Chapter Seventeen Personal Relationships
- Chapter Eighteen Relationships with Children

After providing a short introduction, each chapter describes the measure/s used to identify change, before presenting the primary results. Each chapter concludes with a discussion of these results in relation to the current literature.

Further sections of this report focus on other health outcomes of interest.

- Identifying Potential Risk Markers in Section Five
- **Conclusions and Limitations** are presented in Chapter Twenty Two

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Chapter Seventeen – Personal Relationships

Key Points

- 1. Almost 65% of participants were in a significant relationship at both preand post-deployment, and nearly 90% reported being satisfied with their relationship at pre-deployment.
- 2. **Relationship satisfaction increased or remained the same** between preand post-deployment for 79.5% of participants.
- 3. Fourteen percent of participants reported **relationship breakdown** at postdeployment.
- 4. Fourteen percent of participants also reported feeling **unsupported by their family/partner** while on their most recent deployment.
- 5. **Relationship breakdown** at post-deployment was **significantly associated** with:
 - Being deployed for 9-12 months compared to ≤ 5 months
 - Increases in PTSD symptoms between pre- and post-deployment;
 - Increases in alcohol use between pre- and post-deployment; and
 - Having more co-morbidities at post-deployment
- 6. **Reduced relationship satisfaction and perceived support from family** were also **significantly associated** with the following psychological health factors:
 - Increases in PTSD symptoms between pre- and post-deployment; and
 - Having more co-morbidities at post-deployment
- 7. No significant associations were found between any personal relationship outcomes, and any factors associated with prior deployments.

This chapter is the first of two social health chapters and it presents and discusses some of the findings relating to personal relationships. The chapter begins by briefly defining social health in the context of this report before discussing some of the currently literature. Results are then provided, beginning with a comparison of the significant personal relationship status at pre-deployment, between participants who completed only the pre-deployment, and those who completed both the pre-and postdeployment self-report measure. All subsequent analyses within the result sections include only participants who have completed both the pre- and post-deployment measures. The chapter concludes by discussing the findings pertaining to personal relationships.

17.1 Introduction

A military deployment may enhance as well as contribute to the deterioration of various aspects of a member's social health. Studies have demonstrated that while deployment strengthens workplace friendships as colleagues rely on each other for support [1], relationships with the partners, extended family and friends left behind may stagnate or even deteriorate [2].

There are a number of other risk factors which may be particularly detrimental to family relationships. For example, the length of deployment has been found to impact social health outcomes, with greater time away increasing the likelihood of divorce post-deployment [3]. Military personnel who are exposed to combat trauma on deployment may also be especially likely to experience a deterioration in personal relationships [4, 5].

Outcomes from combat trauma such as PTSD are likely to be the primary contributor to deterioration in social health. For example, Allen et al. [6] found that recent deployment was not directly associated with marital discord, however increased PTSD symptoms resulting from deployment experiences were. This impact on social relationships may occur through associated symptoms of withdrawal [7], emotional numbing and anger [8].

The association between mental disorders and social health is complex. As noted above, while PTSD has been found to be associated with deteriorating social support [9], alcohol misuse also increases the risk of many social problems such as family disintegration [10]. Conversely, high relationship satisfaction has been found to be a protective factor, reducing the association between alcohol misuse and intimate partner violence [11].

17.2 Measures

The following four measures of social health, all of which pertain to family relationships, are used in this chapter to analyse social health:

- 1. Changes to the respondent's **significant intimate relationships** between preand post-deployment. Relationships are defined as:
 - Married and living together
 - Married with unaccompanied spouse
 - Living with partner (ADF recognised)
 - Living with partner (not ADF recognised)
 - In a long term relationship but not living together
- 2. **Relationship satisfaction** measured at post-deployment.
- 3. Contemplating divorce or permanent separation or **relationship breakdown** since the beginning of their most recent deployment to the MEAO.
- 4. Whether the participant thought that they had enough **personal support from their family** during their most recent deployment.

All of these social health measures were from the self-report questionnaire.

17.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and social health as measured by personal relationships?
- 2. Is there an association between **roles on most recent deployment** and social health as measured by personal relationships?
- 3. Is there an association between **total length of time spent on deployment** in the previous three years and social health as measured by personal relationships?
- 4. Is there an association between the **number of previous deployments** and social health as measured by personal relationships?
- 5. Is previous **combat experience** associated social health as measured by personal relationships?
- 6. Is there an association between **change in PTSD Symptoms** between preand post-deployment and social health as measured by personal relationships?
- 7. Is there an association between **change in alcohol use** between pre- and post-deployment and social health as measured by personal relationships?
- 8. Is there an association between the **psychological co-morbid groups** at post-deployment and social health as measured by personal relationships?

17.2.2 Sample Sizes

As noted above (Section 17.2), four measures were used to analyse social health – namely:

- intimate relationships
- relationship satisfaction
- contemplating relationship breakdown
- support from family or partner

While all were included within the self-report questionnaire, a small number of respondents did not answer all of these questions. Therefore, as noted below there are variations in the sample sizes for each measure.

There may also be some variation to the sample sizes used within each of the result sections due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

17.2.2.1 Intimate Relationships

The total sample size used **to identify changes to personal relationships** between pre- and post-deployment was 1307. Of the 1324 participants who completed both a pre- and post-deployment self-report questionnaire 17 were excluded - ten because they did not complete the question at pre- and seven because they did not complete the question at pre- and seven because they did not complete the question at pre- and seven because they did not complete the question.

The total pre-deployment only sample size used **to compare differences in personal relationships** with those participants who had completed both the pre- and post-deployment questionnaire was 533 - 14 participants who only completed the pre-deployment self-deployment questionnaire did not answer this question.

17.2.2.2 Relationship Satisfaction

The total sample size used **to identify changes to relationship satisfaction** was 827. Of the 1324 participants who completed both a pre- and post-deployment self-report questionnaire 497 were excluded – 443 did not complete the question at either pre- and/or post-deployment and 54 provided answers either at pre- and/or post-deployment which were contradictory. For example, participants reporting extremely satisfied at pre- but not applicable at post-deployment.

The total pre-deployment only sample size used **to compare differences in intimate relationships** between those participants who only completed the predeployment questionnaire, and those participants who completed both the pre- and post-deployment questionnaire was 517 as 14 participants who only completed the pre-deployment self-deployment questionnaire did not answer this question.

17.2.2.3 Contemplating Relationship Breakdown

The total sample size used **to identify a potential relationship breakdown at postdeployment** was 879. Of the 1324 participants who completed both a pre- and postdeployment self-report questionnaire 445 were excluded because they did not complete this post-deployment only question.

17.2.2.4 Support from Family/Partner

The total sample size used **to identify support from family and/or partner during deployment** was 1241. Of the 1324 participants who completed both a pre- and post-deployment self-report questionnaire 83 were excluded because they did not complete this post-deployment only question.

17.2.3 Data Analysis

Significant relationship status (Pre- Only, Both), contemplating relationship breakdown (Yes, No) and perceived support from family (Agree, Disagree) were modelled as two level categorical outcomes in a binary logit model. This approach allowed for the associations between the predictors of interest, and each relationship outcome to be examined.

The change in marriage satisfaction between pre- and post-deployment was classified into three change categories ('Increase', 'Decrease' or 'No change'). The change categories were then used as a three level categorical outcome in a multinomial logit model. This approach allowed for the shift in satisfaction between the two time points to be examined. In all models the default reference category was 'No Change'. Where a different reference category was used, this is stated in the text.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

17.3 Results

A comparison of the proportion of the respondents who completed the pre- and postdeployment relationship status question was undertaken (Table 17.1, Appendix X). As can be seen in Table 17.2, an additional 1.2% of participants reported being in a significant relationship at post- compared to pre-deployment.

Table 17.2: Change in relationship status between pre- and post-deployment for responders who
completed at both time-points

Total Sample	Neither at Pre-	At Pre- Only	At Post- Only	At Both Pre-
	nor Post- N(%)	N(%)	N(%)	and Post- N(%)
1307	307 (23.5%)	71 (5.4%)	86 (6.6%)	843 (64.5%)

A comparison of the proportion of the respondents who completed the pre- and postdeployment relationship satisfaction question was undertaken (Table 17.3, Appendix X). As can be seen in Table 17.4, while the majority of participants reported the same level of satisfaction at both pre- and post-deployment, an addition 6.9% of participants reported a deteriorating relationship at post-deployment compared to those who reported that their relationship satisfaction had improved.

 Table 17.4: Change in relationship satisfaction between pre- and post-deployment for responders

 who completed at both time-points

Total Sample	No Change N(%)	Improving N(%)	Deteriorating N(%)
827	545 (65.9%)	112 (13.6%)	170 (20.5%)

An analysis of the proportion of responders, who completed the question regarding contemplating a relationship breakdown at post-deployment, was undertaken. As can be seen in Table 17.5, the majority of participants reported that either they or their partner had seriously suggested divorce or permanent separation since the beginning of their most recent deployment to the MEAO.

Table 17.5: Proportion of participants who had or had not considered divorce or separation reported at post-deployment

Total Sample	Agree N(%)	Disagree N(%)	Not Applicable N(%)
879	123 (14.0%)	727 (82.7%)	29 (3.3%)

An analysis of the proportion of responders, who completed the partner support question at post-deployment, was undertaken (Table 17.6, Appendix X). As can be seen in Table 17.7, the majority of participants reported that their partners or family had supported them during their most recent deployment.

 Table 17.7: Proportion of participants who did or did not receive sufficient support from their partner or family as reported at post-deployment

Total Sample	Agree N(%)	Disagree N(%)	Not Applicable N(%)
879	727 (82.7%)	123 (14.0%)	29 (3.3%)

17.3.1 Length of Most Recent Deployment

17.3.1.1 Significant Relationship Status

Table 17.8 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different 'Length of most recent deployment' categories (n = 913). Using '<=5 months' as the predictor reference, there was no association between the length of most recent deployment and whether or not respondents were or were no longer in a significant intimate relationship at post-deployment.

17.3.1.2 Satisfaction with Marriage

Table 17.9 (Appendix X) shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different 'Length of most recent deployment' categories (n = 827). Using <= 5 months as the predictor reference, and no change as the outcome reference there was no association between the time away on prior deployments and change in relationship satisfaction.

17.3.1.3 Contemplating Relationship Breakdown

Table 17.10 shows the percentage of participants who did and did not report that they had contemplated a relationship breakdown since the beginning of their most recent deployment, for the different 'Length of most recent deployment' categories (n = 850). Using '<=5 months' as the predictor reference, there was a significant association between the length of most recent deployment and whether or not respondents reported contemplating a relationship breakdown (p=0.02).

Length of most recent deployment (category)		Contemplating Relationship breakdown	
	N	Yes	No
<= 5 months	271	11.1%	88.9%
6-7 months	256	14.8%	85.2%
8 months	192	13.0%	87.0%
9-12 months	131	22.9%	77.1%

Table 17.10: Proportion of participants who did and did not report contemplating relationship breakdown by length of most recent deployment

As can be seen in Table 17.10, compared to those respondents who were away for less than or equal to 5 months, those who were away for 9-12 months were more likely to report contemplating a relationship breakdown since the beginning of their most recent deployment (OR=4.39, 95% CI 1.28, 4.47). The significant association between length of most recent deployment and reporting a potential for relationship breakdown is illustrated in Figure 17.1.



Figure 17.1: Percentage of respondents who reported contemplating a relationship breakdown at post-deployment, for each category of deployment length.

17.3.1.4 Perceived Support from Family

Table 17.11 (Appendix X) shows the percentage of participants who did and did not perceive support from family, for the different 'Length of most recent deployment' categories (n = 1092). Using '<=5 months' as the predictor reference, there was no association between the length of most recent deployment and whether or not respondents perceived support from family at post-deployment.

17.3.2 Role on Most Recent Deployment

17.3.2.1 Significant Relationship Status

Table 17.12 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different roles while on deployment (n = 913). Using 'Outside Afghan' as the predictor reference, there was no association between role on deployment and whether or not respondents were, or were no longer, in a significant intimate relationship at post-deployment.

17.3.2.2 Satisfaction with Marriage

Table 17.13 (Appendix X) shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different roles while on deployment (n = 827). Using outside Afghan as the predictor reference, and no change as the outcome reference, there was no association between role on deployment and change in relationship satisfaction.

17.3.2.3 Contemplating a Relationship Breakdown

Table 17.14 (Appendix X) shows the percentage of participants who did and did not report contemplating a relationship breakdown since the beginning of their most recent deployment, for the different role categories (n = 850). Using 'Outside Afghan' as the predictor reference, there was no significant association between role on recent deployment and whether or not respondents reported contemplating a relationship breakdown.

17.3.2.4 Perceived Support from Family

Table 17.15 (Appendix X) shows the percentage of participants who did and did not perceive support from family, for the different role categories (n = 1092). Using

'Outside Afghan' as the predictor reference, there was no significant association between role on recent deployment and whether or not respondents perceived support from their family at post-deployment.

17.3.3 Total Time on Prior Deployments

17.3.3.1 Significant Relationship Status

Table 17.16 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different 'Total time on prior deployment' categories (n = 637). Using 'None' as the predictor reference, there was no association between time away on prior deployments, and whether or not respondents were or were no longer in a significant intimate relationship at post-deployment.

17.3.3.2 Satisfaction with Marriage

Table 17.17 (Appendix X) shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different 'Total time on prior deployment' categories (n = 569). Using 'None' as the predictor reference, and no change as the outcome reference there was no association between time away on prior deployments and change in relationship satisfaction.

17.3.3.3 Contemplating a Relationship Breakdown

Table 17.18 (Appendix X) shows the percentage of participants who did and did not report contemplating a relationship breakdown since the beginning of their most recent deployment, for the different 'Total time on prior deployment' categories (n = 589). Using 'None' as the predictor reference, there was no association between the time away on prior deployments and whether or not respondents reported contemplating a relationship breakdown.

17.3.3.4 Perceived Support from Family

Table 17.19 (Appendix X) shows the percentage of participants who did and did not perceive support from family, for the different 'Total time on prior deployment' categories (n = 791). Using 'None' as the predictor reference, there was no association between the time away on prior deployments and whether or not respondents perceived support from family at post-deployment.

17.3.4 Number of Prior Deployments

17.3.4.1 Significant Relationship Status

Table 17.20 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different 'Number of prior deployment' categories (n = 827). Using 'None' as the predictor reference, there was no association between number of prior deployments, and whether or not respondents were or were no longer in a significant intimate relationship at post-deployment.

17.3.4.2 Satisfaction with Marriage

Table 17.21 (Appendix X) shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different 'Number of prior deployment' categories (n = 756). Using 'None' as the predictor reference, and no change as the outcome reference there was no association between the number of prior deployments and change in relationship satisfaction.

17.3.4.3 Contemplating a Relationship Breakdown

Table 17.22 (Appendix X) shows the percentage of participants who did and did not report contemplating a relationship breakdown since the beginning of their most recent deployment, for the different 'Number of prior deployment' categories (n = 774). Using 'None' as the predictor reference, there was no association between the time away on prior deployments and whether or not respondents reported contemplating a relationship breakdown.

17.3.4.4 Perceived Support from Family

Table 17.23 (Appendix X) shows the percentage of participants who did and did not perceive support from family, for the different 'Number of prior deployment' categories (n = 986). Using 'None' as the predictor reference, there was no association between the number of prior deployments and whether or not respondents perceived support from family at post-deployment.

17.3.5 Previous Combat Exposure

17.3.5.1 Significant Relationship Status

Table 17.24 (Appendix X) shows the percentage of participants exposed to previous combat, who were and who were no longer in a significant intimate relationship at post-deployment (n = 880). There was no significant association between previous combat exposure and relationship status at post-deployment.

17.3.5.2 Satisfaction with Marriage

Table 17.25 (Appendix X) shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for those with and without previous combat exposure (n = 797). There was no association between previous combat exposure and change in marriage satisfaction between pre- and post-deployment.

17.3.5.3 Contemplating a Relationship Breakdown

Table 17.26 (Appendix X) shows the percentage of participants who did and did not report contemplating a relationship breakdown since the beginning of their most recent deployment, for those who had and had not been exposed to previous combat (n = 815). There was no significant association between previous combat exposure and whether or not respondents reported contemplating a relationship breakdown.

17.3.5.4 Perceived Support from Family

Table 17.27 (Appendix X) shows the percentage of participants exposed to previous combat, who did and did not perceive support from family at post-deployment (n = 1051). There was no significant association between previous combat exposure and whether respondents did or did not perceive support from their family.

17.3.6 PTSD Symptoms

17.3.6.1 Significant Relationship Status

Table 17.28 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different PTSD Symptom change categories (Increase, Decrease, No change) as measured by the PCL-C (n = 851). Using 'No change' as the predictor reference, there was no association between the change in PTSD symptoms and change in relationship status between pre- and post-deployment.

17.3.6.2 Satisfaction with Marriage

Table 17.29 shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different PTSD Symptom change categories (Increase vs Decrease/No change) as
measured by the PCL-C (n = 777). Using 'Increase' as the predictor reference, and 'No change' as the outcome reference there was a significant association between the change in PTSD symptoms between pre- and post-deployment, and the change in relationship satisfaction (p<0.0001).

Table 17.29: Proportion of participants with change in marriage satisfaction between pre- and postdeployment (Increase, decrease, no change) for each PTSD symptom change category (Increase, Decrease/No change)

PTSD symptom change (category)	N	Marriage satisfaction Increase	Marriage Satisfaction Decrease	Marriage satisfaction No change
PTSD Symptom Increase	76	5.3%	21.0%	73.7%
PTSD Symptom Decrease/No change	701	2.9%	5.7%	91.4%

As can be seen in Table 17.29, a greater proportion of participants whose PTSD symptoms increased compared to those who decreased or didn't change between pre- and post-deployment, also had a decrease in relationship satisfaction (OR=4.27, 95% CI 2.23, 8.20). The significant association between change in PTSD symptoms and marriage satisfaction is illustrated in Figure 17.2.





17.3.6.3 Contemplating a Relationship Breakdown

Table 17.30 shows the percentage of participants who reported contemplating a relationship breakdown, for the different PTSD symptom change categories (Increase, Decrease, No change) as measured by the PCL-C (n = 796). Using 'No change' as the predictor reference, there was a significant association between the change in PTSD symptoms between pre- and post-deployment and whether or not respondents reported contemplating a relationship breakdown since the beginning of their most recent deployment (p<0.0001).

 Table 17.30: Proportion of participants in each PTSD symptom category, who did or did not report

 contemplating a relationship breakdown since beginning of most recent deployment

PTSD symptom change between pre- and post-deployment (category)		Contemplating a Relationship breakdown	
	N	Yes	No
PTSD symptom	77	40.3%	59.7%
Increase			
PTSD symptom	11	18.2%	81.8%
Decrease			
PTSD symptom No change	708	11.6%	88.4%

As can be seen in Table 17.30, compared to those whose PTSD symptom scores didn't change, a greater proportion of participants whose PTSD symptoms increased between pre- and post-deployment reported contemplating a relationship breakdown (OR=5.11, 95% CI 3.04, 8.62). The significant association between change in PTSD symptom scores and contemplating a relationship breakdown is illustrated in Figure 17.3.





17.3.6.4 Perceived Support from Family

Table 17.31 shows the percentage of participants who did and did not perceive support from family, for the different PTSD symptom change categories (Increase, Decrease, No change) (n = 1039). Using 'No change as the predictor reference, there was a significant association between the change in symptom scores between pre- and post-deployment and whether or not respondents perceived support from family at post-deployment (p=0.001).

Table 17.31: Proportion of participants in each PTSD symptom change category, who did or did not perceive support from family at post-deployment

PTSD symptom change between pre- and post-deployment (category)		Perceived support from family	
	N	Agree	Disagree
PTSD symptom	106	86.8%	13.2%
Increase			
PTSD symptom	17	88.2%	11.8%
Decrease			
PTSD symptom No	916	95.5%	4.5%
change			

As can be seen in Table 17.31, compared to those whose PTSD symptom scores didn't change, participants whose PTSD symptoms increased between pre- and post-deployment were less likely to perceive support from family at post-deployment (OR=0.31, 95% CI 0.16, 0.60). The significant association between change in PTSD symptom scores and perceived support from family is illustrated in Figure 17.4.





17.3.7 AUDIT

17.3.7.1 Significant Relationship Status

Table 17.32 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different AUDIT change categories (Increase, Decrease, No change) (n = 841). Using 'No change' as the predictor reference, there was no association between the change in AUDIT scores and change in relationship status between pre- and post-deployment.

17.3.7.2 Satisfaction with Marriage

Table 17.33 (Appendix X) shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different AUDIT change categories (Increase, Decrease, No change) (n = 772). Using 'No change' as the predictor reference, and 'No change' as

the outcome reference there was no significant association between the change in AUDIT scores from pre- to post-deployment, and the change in relationship satisfaction.

17.3.7.3 Contemplating a Relationship Breakdown

Table 17.34 shows the percentage of participants who did or did not report contemplating a relationship breakdown, for the different AUDIT change categories (Increase, Decrease, No change) (n = 788). Using 'No change' as the predictor reference, there was a significant association between the change in AUDIT scores between pre- and post-deployment and whether or not respondents reported contemplating a relationship breakdown since the beginning of their most recent deployment (p=0.0003).

 Table 17.34: Proportion of participants in each AUDIT change category, who did or did not report

 contemplating a relationship breakdown since beginning of most recent deployment

AUDIT change (category)		Contemplating a Relationship breakdown	
	N	Yes	No
AUDIT Increase	103	28.2%	71.8%
AUDIT Decrease	94	11.7%	88.3%
AUDIT No change	591	13.2%	86.8%

As can be seen in Table 17.34, compared to those whose AUDIT scores didn't change, a greater proportion of participants whose AUDIT scores increased between pre- and post-deployment reported contemplating a relationship breakdown (OR=2.71, 95% CI 1.63, 4.49). The significant association between change in AUDIT scores and contemplating a relationship breakdown is illustrated in Figure 17.5.





17.3.7.4 Perceived Support from Family

Table 17.35 (Appendix X) shows the percentage of participants who did and did not perceive support from family, for the different AUDIT change categories (Increase, Decrease, No change) (n = 1022). Using 'No change as the predictor reference, there was no significant association between the change in AUDIT scores between

pre- and post-deployment and whether or not respondents perceived support from family at post-deployment.

17.3.8 Psychological Co-morbidity

17.3.8.1 Significant Relationship Status

Table 17.36 (Appendix X) shows the percentage of participants who were and who were no longer in a significant intimate relationship at post-deployment, for the different co-morbidity categories (n = 901). Using 'None' as the predictor reference, there was no association between the number of psychological conditions at post-deployment and change in relationship status between pre- and post-deployment.

17.3.8.2 Satisfaction with Marriage

Table 17.37 shows the percentage of participants whose marriage satisfaction increased, decreased or didn't change between pre- and post-deployment, for the different co-morbidity categories (n = 816). Using 'None' as the predictor reference, and 'No change' as the outcome reference there was a significant association between the number of psychological conditions at post-deployment, and the change in relationship satisfaction (p=0.008).

Number of co-morbidities (post-deployment)	N	Marriage satisfaction Increase	Marriage Satisfaction Decrease	Marriage satisfaction No change
No Psychological Conditions	453	2.7%	4.6%	92.7%
One Psychological Condition	224	2.2%	8.0%	89.7%
Two Psychological Conditions	90	5.6%	11.1%	83.3%
Three Psychological Conditions	49	4.1%	20.1%	75.5%

 Table 17.37: Proportion of participants with change in marriage satisfaction between pre- and postdeployment (Increase, decrease, no change) for co-morbidity categories

As can be seen in Table 17.37, compared to those respondents with no psychological conditions at post-deployment, those with 2 (p=0.02, OR=2.45, 95% CI 1.10, 5.46) or 3 (p=0.0002, OR=4.95, 95% CI 2.14, 11.49) were more likely to have a decrease in their relationship satisfaction. The significant association between number of co-morbid psychological conditions and marriage satisfaction is illustrated in Figure 17.6, which shows the probability of satisfaction increasing, decreasing or not changing, with increasing co-morbidities.





17.3.8.3 Contemplating a Relationship Breakdown

Table 17.38 shows the percentage of participants who reported contemplating a relationship breakdown, for the different co-morbidity categories (n = 840). Using 'None' as the predictor reference, there was a significant association between number of psychological conditions at post-deployment and whether or not respondents reported contemplating a relationship breakdown since the beginning of their most recent deployment (p<0.0001).

Number of co-morbidities	Contemplating a relationship breakdown			
(post-deployment)	Ν	Yes	No	
No Psychological	464	9.3%	90.7%	
Conditions				
One Psychological	235	13.6%	86.4%	
Condition				
Two Psychological	92	28.3%	71.7%	
Conditions				
Three Psychological	49	44.9%	55.1%	
Conditions				

 Table 17.38: Proportion of participants in each co-morbidity category, who did or did not report

 contemplating a relationship breakdown since beginning of most recent deployment

As can be seen in Table 17.38, compared to those respondents with no psychological conditions at post-deployment, those with 2 (p<0.0001, OR=3.85, 95% CI 2.19, 6.75) or 3 (p<0.0001, OR=8.19, 95% CI 4.24, 15.83) were more likely to report contemplating a relationship breakdown. The significant association between number of co-morbid psychological conditions and contemplating a relationship breakdown is illustrated in Figure 17.7.



Figure 17.7: Percentage of respondents in each co-morbidity category reporting contemplating a relationship breakdown at post-deployment.

17.3.8.4 Perceived Support from Family

Table 17.39 shows the percentage of participants who did and did not perceive support from family, for the different co-morbidity categories (n = 1092). Using 'None' as the predictor reference, there was a significant association between the number of co-morbidities at post-deployment and whether or not respondents perceived support from family at post-deployment.

Number of co-	Perceived support from family		
morbidities (post- deployment)	N	Agree	Disagree
No Psychological Conditions	570	96.0%	4.0%
One Psychological Condition	320	94.7%	5.3%
Two Psychological Conditions	139	91.4%	8.6%
Three Psychological Conditions	63	88.9%	11.1%

Table 17.39: Proportion of participants in each co-morbidity category, who did or did not perceive support from family at post-deployment

As can be seen in Table 17.39, compared to those respondents with no comorbidities at post-deployment, those with 2 (p=0.02, OR=0.43, 95% CI 0.21, 0.91) or 3 (p=0.01, OR=0.33, 95% CI 0.13, 0.82) were less likely to perceive support from their family at post-deployment. The significant association between number of comorbidities and perceived support from family is illustrated in Figure 17.8.





17.4 Summary of Results

Table 17.40 summarises the key findings presented in this results section. Following the summary of results is a discussion section which draws together the findings presented above with reference to literature which has already been published.

Question	Significant Associations
Q1. Length of most recent deployment	Compared to those who were away for ≤ 5 months, those who were away for 9 to 12 months were more likely to report contemplating a relationship breakdown.
Q2. Role on most recent deployment	Nil
Q3. Total time on prior deployments	Nil
Q4. Number of prior deployments	Nil
Q5. Previous combat experience	Nil
Q6. Changes to PTSD symptoms	Compared to those who decreased or didn't change, a greater proportion of participants with increased PTSD symptoms also had a decrease in relationship satisfaction.
	Compared to those who didn't change, a greater proportion of participants whose PTSD symptoms increased also reported contemplating a relationship breakdown.
	Compared to those who didn't change, a greater proportion of participants with increased PTSD symptoms also were less likely to perceive support from family during deployment.

Table 17.40: Summary of key findings presented in this chapter

Q7. Changes in alcohol use	Compared to those who didn't change, a greater proportion of participants whose alcohol use increased reported contemplating a relationship breakdown.
Q8. Psychological co-morbidity at post-deployment	Compared to those with no co-morbidities, those with 2 or 3 psychological conditions were more likely to have a decrease in relationship satisfaction.
	Compared to those with no co-morbidities, those with 2 or 3 psychological conditions were more likely to report contemplating a relationship breakdown
	Compared to those with no co-morbidities, those with 2 or 3 were less likely to perceive support from their family during deployment

17.5 Discussion

The majority of participants in this study reported being in a significant relationship at both pre- and post-deployment (64.5%). Well over half of these participants were equally as satisfied, or even more satisfied with their relationship at post-deployment (79.5%) compared to pre-deployment. The MEAO Census Study [12] also found that the majority of their participants were either satisfied or extremely satisfied with their relationship, although the proportions in their study were slightly higher (89.7%). One possible reason for these the higher levels of relationship satisfaction is that the MEAO Census study was conducted retrospectively, sometimes years after the participant's last deployment. This meant that at least in some cases, participants in the MEAO Census Study had an opportunity to overcome any challenges that arose as a consequence of their last deployment. Likewise, the recently complete Timor-Leste Family Study [13] also reported that almost all of the couples they had surveyed (92%) were satisfied or extremely satisfied with their relationship. However, only a small percentage (8%) of the ADF members were deployed at the time of data collection.

While only 14% of participants in this study reported that they or their partner had seriously considered a divorce or permanent separation, almost the same proportion also felt that their partners and/or family had not supported them on their last deployment. In comparison, only 8.6% of MEAO Census Study participants who had deployed to the MEAO before December 2009 reported receiving insufficient support from their family.

17.5.1 Associations

While the majority of participants reported good social health at post-deployment, adverse social health outcomes were associated with length of deployment, as well as increases in symptoms of PTSD and alcohol use between pre- and post-deployment; and co-morbid psychological conditions at post-deployment. These associations will now be discussed.

17.5.2 Length of Most Recent Deployment

The findings from this study suggest that ADF members on longer deployments, specifically those greater than nine months, were more than four times more likely to report that they or their partner had seriously considered a divorce or permanent separation than those who were only away for up to five months. While deployment may strengthen workplace friendships and collegial support networks [1], relationships with the partners, family and friends left behind may stagnate or even deteriorate [2]. It is often not until the member has had time to resettle into their non deployment lives that they are able to reconnect with their significant others outside

of the military. In some circumstances, even after considerable time, reconnecting with others may be difficult. Nevertheless, those closest to us are likely to have the strongest impact upon our social health and therefore it is of concern that some participants are experiencing difficulties with their partner or spouse immediately after deployment. The impact of these prolonged deployments on relationships is a matter of some importance.

Military studies have tended to focus on the interconnection between social and mental health. For example, Operation Iraq Freedom and Operation Enduring Freedom veterans who reported higher resilience and social support scores were found to have less post-traumatic stress and depressive symptoms [14]. A large study of UK peacekeepers also found that having someone to talk to, whether that be informally with a partner or military friend, or formally with welfare or medical services, lowered levels of distress [1].

17.5.3 PTSD Symptoms

Social support is an issue of critical interest to the onset of PTSD. A longitudinal study by Phillip et al., for example, found that five or more close personal friends at follow-up (between three to five years after recruitment), was associated with a significant reduction in the odds of developing PTSD, even in those personnel who had combat experience [15]. Likewise, a study designed to evaluate a peer-support program provided to troops while on deployment, found that personnel who reported access to social support during deployment were less likely to develop symptoms consistent with a PTSD diagnosis [16].

This study has also shown a significant association between PTSD symptoms between pre- and post-deployment and social health. Participants, who experienced an increase in PTSD symptoms, also experienced a decrease in relationship satisfaction, an increase in relationship breakdown and were less likely to perceive that the support they received from their family and/or partner while on deployment was adequate. However, even this prospective design did not resolve the issues of cause and effect.

In summary, it should not be assumed that reduced social support led to increases in PTSD symptoms in this study. Rather, the tendency for chronic PTSD sufferers to withdraw into themselves, may account for some of the breakdown in social relationships [7]. A study of 468 US army national guards who had recently experienced combat [17] found that PTSD symptoms negatively impacted on family members. This is consistent with findings from a qualitative study of peacekeepers who met PTSD criteria, showing that emotional numbing and anger contributed to breakdowns in relationships. Additional symptoms, such as reluctance to discuss the deployment experience with their partners in case they were seen as emotionally vulnerable, further exacerbated the strain on personal relationships [8].

Nevertheless, while PTSD may lead to deteriorating social health, as mentioned above, studies have also found that a lack of social support is associated with PTSD [9]. Highlighting the interconnected nature of these variables, Monson et al [18] argue that couples who experience difficulties adjusting to life after deployment, may in turn have increased PTSD symptoms and decreased social support.

17.5.4 AUDIT

This study has also demonstrated an association between alcohol use and social health. Participants who increased their alcohol usage between pre- and post-deployment were almost three times as likely to report that they or their partner had seriously considered a divorce or permanent separation. Similar to PTSD, the relationship between alcohol and social health is complex. Some studies have suggested that marriage may be protective against alcohol misuse and AUD [19], although Yarvis and Schiess [20] found no impact. In the case of alcohol use, the nature of the family environment is likely to have an important moderating impact on the behaviours associated with alcohol consumption. A limitation of this study is that the multivariate nature of the relationship between PTSD and alcohol use has not been examined.

While alcohol consumption may or may not be impacted by relationship status, alcohol abuse has been found to increase the risk of many social problems such as family disintegration [10]. In a recent study involving over 54,000 US active duty Air Force personnel, alcohol abuse was a significant risk factor for intimate partner violence in men, and this association was moderated by two family variables (relationship satisfaction and parent-child satisfaction), one community variable (community safety), in addition to years in the military, marital length and family income. Importantly, however, high relationship satisfaction was found to be a protective factor, reducing the association between alcohol misuse and intimate partner violence [11].

17.5.5 Co-morbidity

Finally, this study also found that having two or three co-morbid psychological conditions at post-deployment was associated with a reduction in social health. In particular, co-morbidity was significantly associated with a decrease in relationship satisfaction, an increase in possible relationship breakdown, and reduced likelihood that the participant perceived that they received enough support from their family or partner during their most recent deployment. The issues of cause and effect are again paramount issues in considering this association.

Individuals with a mental disorder may be more likely to have a negative view of their social health. A study of 272 Operations Iraqi and Enduring Freedom veterans from Connecticut [21] found that decreased perceptions of unit and post-deployment social support were associated with both PTSD diagnosis as well as intense feelings of depression and indifference to the world around them. While one explanation is that social isolation is a risk factor for mental illness, it is also possible that PTSD and depression negatively affect a how a person views the world and their relationships with other people. The fact that the individual with symptoms is reporting the quality of their social environment highlights the potential to confound this relationship. In the ideal design, the social relationships would be independently rated to prevent this contamination effect.

While a number of studies have also found that poor social health may be associated with a decline in general mental health of serving personnel, often the issues of cause and effect are not fully considered. However the findings are important note as they document the disruption of social relationships associate with the psychological consequences of combat. For example, a study involving UK military personnel found that reservists who reported difficulties with post-deployment social functioning were also at greater risk for a range of mental disorders including PTSD and alcohol misuse [22]. For US female service members, however, the association was less clear. While the lack of social support immediately after deployment significantly contributed to the onset of PTSD, depression and anxiety symptoms, the

presence of social conflict was also associated with an increase in symptoms for those who were already at risk [23]. This suggests that the participants who are already dealing with a number of psychological conditions at post-deployment may find it particularly difficult to also deal with re-establishing intimate relationships with their partners.

17.6 Summary

This study has shown that the majority of ADF members surveyed did not have a change in their relationship status at post-deployment, were satisfied with their relationships, and felt well-supported by their family while on deployment. A number of respondents did have reduced satisfaction, and reported discussing divorce or separation with their partner following deployment (relationship breakdown). A similar proportion also reported insufficient support from their family or partner while on deployment. Interestingly, relationship breakdown was the social health outcome that showed the most associations with both deployment specific and psychological health factors.

While longer recent deployments were associated with an increased likelihood of possible relationship breakdown, it was psychological conditions that shared the greatest associations with social health outcomes, but is unclear whether these effects were caused by or a result of the psychological condition. Specifically, increased PTSD symptoms and alcohol use were associated with relationship breakdown, and increased PTSD symptoms with reduced relationship satisfaction and perceived support from family. Finally, having a higher number of psychological co-morbidities at post-deployment was also associated with each of these three outcomes. In essence, the disruptive effect of psychological disorders and distress on families post-deployment should not be minimised.

In summary, it is important to acknowledge not only the bi-directional nature of these associations, but also the fact that these social health factors are interconnected, and the analyses presented here did not investigate this. For example, as mentioned earlier, a perception of lack of support from family while on deployment may be associated with reduced relationship satisfaction. Likewise, reduced satisfaction may translate to increased risk for relationship breakdown.

The next chapter focuses on the **children of these participants** (Chapter Eighteen). Once again, after a short introduction, an explanation of the principal measures is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature.

Following sections of this report focus on:

- Identifying Possible Risk Markers in Section Five
- **Conclusions and Limitations** in Chapter Twenty Two

17.7 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified. In addition, a number of other social health outcomes were measured but due to time constraints were not included in these analyses. These include changes in the degree of community participation between pre- and postdeployment, unit cohesion while on deployment and support from the military after returning home. A number of studies have also found an association between social health and neurocognitive outcomes. Further analyses regarding these objective measures of cognitive functioning and social health outcomes are required.

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Chapter Eighteen – Relationships with Children

Key Points

- 1. Fifty-five percent of participants **perceived that their military career had a negative impact on their children** at post-deployment.
- 2. Twenty-two percent of participants **perceived problems with their children** while on deployment.
- 3. Perceived problems with children while on deployment were associated with **prior combat exposure**.
- 4. Perceived problems with children while on deployment, and perceived negative impact on children at post-deployment were **significantly associated** with:
 - prior combat exposure,
 - increases in PTSD symptoms between pre- and post-deployment; and
 - having more co-morbidities at post-deployment.
- 5. No significant associations were found between problems with or perceived impacts on children, and any factors associated with current deployments.

This chapter presents and discusses findings relating to respondents relationships with their children. The chapter begins by discussing the current literature regarding the children of military personnel. Results are then presented for participants who completed both the pre- and post-deployment measures. The chapter concludes by discussing the significant findings pertaining to relationships between military personnel and their children.

18.1 Introduction

While professional relationships are important for military personnel [1], relationships with partners and children make a considerable contribution to military members' social health and general wellbeing [2]. However deployment is both a challenging time for the individual going, as well as any family members left behind. Children in particular, have been shown to be vulnerable during this period [3]. While there is a suggestion that some cope well with these challenges [4], a number of studies have found that children of deploying personnel are deeply affected by the experience [5-7].

Many of the studies which consider the impact of deployment on children focus on psychological and emotional outcomes. It is possible that as many as one in four children may experience a psycho-social problem as a result of their parent's deployment [8]. Jensen [9] for example, found modest increases in self reported depression for children with deployed parents, compared to a non-deployed control

group. While generally children of deployed personnel may be at greater risk of experiencing psychological symptoms, there appear to be differences dependent on the child's age. Huebner et al [10] looked specifically at teenagers and found they experienced a wide range of emotional challenges during the time that one of their parents was away on deployment. In comparison, Chartrand et al [11] found that younger children (approximately 3 years of age), were more likely to exhibit behavioural difficulties compared to children of a similar age group who did not have a deploying parent. Finally, the number of deployments also seems to make a difference. For example Barker and Berry [12] found that the children whose parents had deployed multiple times were at greater risk of exhibiting challenging behaviour.

Decreases in psychological health of some children may in turn impact on the wellbeing of the deployed parent. Very few studies have, however, directly considered the consequences that come from dealing with these types of challenges while on deployment. Nevertheless, some work has been done on the types of challenges veterans face upon their return from deployment. For example Basham [13] found that instead of a relaxing environment in which to recover from the effects of deployment, the home and family often becomes an additional source of stress. These challenges can be further aggravated by some of the psychological symptoms which can be experienced by some members upon return from deployment, including a feeling of being distant and/or cut-off from family members [14, 15]. This in turn places a further strain on the parent-child relationship which may already be struggling as a result of the parent leaving the family home in the first instance [16].

18.2 Measures

The following two social health measures were used to assess the impact of deployment on children:

- 5. Whether there were any **problems with their children** during their most recent deployment.
- 6. Perceived **impact of the respondent's military career on their children** at post-deployment.

Both measures were from the self-report questionnaire.

18.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and impacts on children?
- 2. Is there an association between **role on most recent deployment** and impacts on children?
- 3. Is there an association between **total length of time spent on deployment** in the previous three years and impacts on children?
- 4. Is there an association between the **number of previous deployments** and impacts on children?
- 5. Is previous combat exposure associated with impacts on children?
- 6. Is there an association between **change in PTSD symptoms** between preand post-deployment and impacts on children?

- 7. Is there an association between **change in Alcohol use** between pre- and post-deployment and impacts on children?
- 8. Is there an association between **psychological co-morbid groups at postdeployment** and impacts on children?

18.2.2 Sample Sizes

As noted above (Section 18.2), two measures were used to analyse social health – namely:

- problems with children
- impact on children

While these items were included within the self-report questionnaire, a small number of respondents did not answer each of these questions. Therefore, as noted below there are variations in the sample sizes for each measure.

There may also be some variation to the sample sizes used within each of the result sections due to missing data in other measures. Where this is the case, sample sizes are noted immediately prior to the presentation of each result.

18.2.2.1 Problems with Children While on Deployment

The total sample size used **to identify problems with children while on deployment** was 510. Of the 1324 participants who completed both a pre- and postdeployment self-report questionnaire 84 were excluded because they did not complete this post-deployment only question. A further 730 who responded 'not applicable' to this item were also excluded.

18.2.2.2 Perceived Impact on Children

The total sample size used **to identify negative perceived impact on children at post-deployment** was 621. Of the 1324 participants who completed both a pre- and post-deployment self-report questionnaire 131 were excluded because they did not complete the question at post-deployment. A further 574 participants responded 'not applicable' to the question at post-deployment, therefore were also excluded.

18.2.3 Data Analysis

Responses to whether there were any **problems with their children** during their most recent deployment and perceived **impact of the respondent's military career on their children** at post-deployment were categorised as 'yes' or 'no'. These were then used as two level categorical outcomes in binary logit models.

The following section begins by presenting descriptive tables, including results for different population sub-groups. While there are differences between the various sub-groups, the purpose of this report was not to identify prevalence in sub-groups. In addition, the small numbers in some of the sub-groups may mean that there is not sufficient power to detect statistically significant differences. However, all models were adjusted for gender (male, female), Service (Army, Navy, Air Force), rank (officer, non-commissioned officer, other ranks), and age (in years), sub-group differences will not be discussed.

18.3 Results

An analysis of the proportion of the respondents who did and did not perceive that there was a problem with their children while on deployment was conducted (Table 18.1, Appendix Y). As can be seen in Table 18.2, the majority of participants who had

children at the time of their deployment and answered this question, did not report a problem with their children while on deployment.

Total Sample	There Was a	There Was Not a
N	Problem N (%)	Problem N (%)
510	112 (22.0%)	398 (78.0%)

Table 18.2: Summary of perceived problems with children while on deployment

An analysis of the proportion of the respondents who did and did not perceive a negative impact of their military commitments on their children was conducted (Table 18.3, Appendix Y). As can be seen in Table 18.4, the majority of participants who had children at the time of their deployment and answered this question, did not report a problem with their children at post-deployment.

Total Sample N	Negative impact	No negative impact
621	344 (55.0%)	277 (45.0%)

18.3.1 Length of Most Recent Deployment

18.3.1.1 Perceived problems with children

Table 18.5 (Appendix Y) shows the percentage of participants who did and did not perceive problems with their children for the different 'Length of most recent deployment' categories (n = 510). Using '<=5 months' as the predictor reference, there was no association between the length of most recent deployment and whether or not respondents perceived problems with their children at post-deployment.

18.3.1.2 Perceived impact on children

Table 18.6 (Appendix Y) shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for the different 'Length of most recent deployment' categories (n = 621). Using '<=5 months' as the predictor reference, there was no association between the length of most recent deployment and whether or not respondents perceived a negative impact on their children.

18.3.2 Role on Most Recent Deployment

18.3.2.1 Perceived problems with children

Table 18.7 (Appendix Y) shows the percentage of participants who did and did not perceive problems with their children, for each role on recent deployment (n = 510). Using 'Outside Afghan' as the predictor reference, there was no association between role on recent deployment and whether or not respondents perceived problems with their children.

18.3.2.2 Perceived impact on children

Table 18.8 (Appendix Y) shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment, for the different 'Total time on prior deployment' categories (n = 621). Using 'None' as the predictor reference, there was no association between the time away on prior deployments and whether or not respondents perceived a negative impact on their children.

18.3.3 Total Time on Prior Deployments

18.3.3.1 Perceived problems with children

Table 18.9 (Appendix Y) shows the percentage of participants who did and did not perceive problems with their children for the different 'Total time on prior deployment' categories (n = 344). Using 'None' as the predictor reference, there was no association between the time away on prior deployments and whether or not respondents perceived problems with their children at post-deployment.

18.3.3.2 Perceived impact on children

Table 18.10 (Appendix Y) shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for the different 'Total time on prior deployment' categories (n = 415). Using 'None' as the predictor reference, there was no association between the time away on prior deployments and whether or not respondents perceived a negative impact on their children.

18.3.4 Number of Prior Deployments

18.3.4.1 Perceived problems with children

Table 18.11 (Appendix Y) shows the percentage of participants who did and did not perceive problems with their children for the different 'Number of prior deployment' categories (n = 464). Using 'None' as the predictor reference, there was no association between the number of prior deployments and whether or not respondents perceived problems with their children while on deployment.

18.3.4.2 Perceived impact on children

Table 18.12 (Appendix Y) shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for the different 'Number of prior deployment' categories (n = 569). Using 'None' as the predictor reference, there was no association between the number of prior deployments and whether or not respondents perceived a negative impact on their children.

18.3.5 Previous Combat Exposure

18.3.5.1 Perceived problems with children

Table 18.13 shows the percentage of participants who did and did not perceive problems with their children while on deployment for those with and without previous combat exposure (n = 495).

Previous combat exposure	N	Perceived problems with children	No perceived problems with children
Exposed	62	29.0%	71.0%
Unexposed	433	21.7%	78.3%

 Table 18.13: Percentage of respondents with previous combat exposure, who did and did not perceive problems with their children while on deployment

There was a significant association between previous combat exposure and whether or not respondents perceived problems with their children (p=0.02). Compared to those respondents who had not had prior combat exposure, those who had were significantly more likely to perceive problems with their children (OR = 2.11, 95% CI 1.10, 4.05). This association is illustrated below in Figure 18.1



Figure 18.1: Percentage of respondents with and without prior combat exposure who perceived problems with their children while on deployment.

18.3.5.2 Perceived impact on children

Table 18.14 (Appendix Y) shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for those with and without previous combat exposure (n = 600). There was no significant association between previous combat exposure and perceived negative impact on children.

18.3.6 PCL-C

18.3.6.1 Perceived problems with children

Table 18.15 (Appendix Y) shows the percentage of participants who did and did not perceive problems with their children for the different PCL-C change categories (Increase, Decrease, No change) (n = 488). Using 'No change' as the predictor reference, there was no significant association between change in PCL-C score between pre- and post-deployment, and whether or not respondents perceived problems with their children while on deployment.

18.3.6.2 Perceived impact on children

Table 18.16 shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for the different PCL-C change categories (Increase, Decrease, No change) (n = 591).

PCL-C change (category)	N	No negative impact at post- deployment	Negative impact at post- deployment
PCL-C Increase	60	18.3%	81.7%
PCL-C Decrease	10	30.0%	70.0%
PCL-C No change	521	48.7%	51.3%

Table 18.16: Percentage of respondents who did and did not perceive a negative impact on their children at post-deployment for each PCL-C change category.

Using 'No change' as the predictor reference, there was a significant association between Change in PCL-C score and whether or not respondents perceived a

negative impact on their children (<0.0001). As can be seen in Table 18.16, a greater proportion of participants whose PCL-C increased compared to those who didn't change between pre- and post-deployment, perceived a negative impact of their military commitments on their children (OR=4.28, 95% CI 2.15, 8.54). This association is illustrated below in Figure 18.2



Figure 18.2: Percentage of respondents in each PCL-C change category who perceived a negative impact of their military commitments on their children.

18.3.7 AUDIT

18.3.7.1 Perceived problems with children

Table 18.17 (Appendix Y) shows the percentage of participants who did and did not perceive problems with their children for the different AUDIT change categories (Increase, Decrease, No change) (n = 479). Using 'No change' as the predictor reference, there was no association between change in AUDIT score between preand post-deployment, and whether or not respondents perceived problems with their children while on deployment.

18.3.7.2 Perceived impact on children

Table 18.18 (Appendix Y) shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for the different AUDIT change categories (n = 573). Using 'No change' as the predictor reference, there was no association between Change in AUDIT score between pre- and post-deployment and whether or not respondents perceived a negative impact on their children.

18.3.8 Psychological Co-morbidities

18.3.8.1 Perceived problems with children

Table 18.19 shows the percentage of participants who did and did not perceive problems with their children for the different co-morbid categories (n = 510).

 Table 18.19: Percentage of respondents in each co-morbidity category who did and did not perceive problems with their children while on deployment.

Number of co- morbidities at post- deployment	N	Perceived problems with children	No perceived problems with children
No Psychological Conditions	269	18.2%	81.8%
One Psychological Condition	141	27.7%	72.3%
Two Psychological Conditions	68	26.5%	73.5%
Three Psychological Conditions	32	18.7%	81.3%

Using 'None' as the predictor reference, there was a significant association between the number of psychological conditions at post-deployment and whether or not respondents perceived problems with their children while on deployment (p=0.02). Compared to those respondents who had no psychological conditions at post-deployment, those who had 1 (p=0.007, OR = 2.00, 95% CI 1.21, 3.32) or 2 (p=0.02, OR = 2.12, 95% CI 1.09, 4.10) were significantly more likely to perceive problems with their children while on deployment. This association is illustrated below in Figure 18.3.





18.3.8.2 Perceived impact on children

Table 18.20 shows the percentage of participants who did and did not perceive a negative impact of their military commitments on their children at post-deployment for the different psychological co-morbid categories (n = 614).

 Table 18.20: Percentage of participants in each co-morbidity category who did and did not perceive a negative impact on their children at post-deployment.

Number of co- morbidities at post-deployment	N	No negative impact at post- deployment	Negative impact at post- deployment
No Psychological Conditions	334	52.1%	47.9%
One Psychological Condition	181	43.1%	56.9%
Two Psychological Conditions	65	27.7%	72.3%
Three Psychological Conditions	34	14.7%	85.3%

Using 'None' as the predictor reference, there was a significant association between the number of psychological conditions at post-deployment and whether or not respondents perceived a negative impact on their children (<0.0001). Compared to those respondents who had no psychological conditions at post-deployment, those who had 1 (p=0.02, OR = 1.55, 95% CI 1.06, 2.26), 2 (p=0.0001, OR = 3.31, 95% CI 1.81, 6.06) or 3 (p=0.0002, OR = 6.75, 95% CI 2.50, 18.24) were significantly more likely to perceive a negative impact of their military commitments on their children. This association is illustrated below in Figure 18.4.



Figure 18.4: Percentage of respondents in each co-morbidity category who perceived a negative impact of their military commitments on their children at post-deployment.

18.4 Summary of Results

Table18.21 summarises the key findings presented in this results section. Following the summary of results is a discussion section which draws together the findings presented above with reference to literature which has already been published.

Question	Negative Impact Significant Associations	Problems with Children Significant Associations
Q1. Length of most recent deployment	Nil	Nil
Q2. Role on most recent deployment	Nil	Nil
Q3. Total time on prior deployments	Nil	Nil
Q4. Number of prior deployments	Nil	Nil
Q5. Previous combat experience	Nil	Compared to those who had not, respondents who had prior combat exposure were significantly more likely to perceive problems with their children while on deployment.
Q6. Changes to PTSD symptoms	Compared to those who didn't change, a significantly greater proportion of participants whose PCL-C increased between pre- and post-deployment were likely to perceive that their military career had a negative impact on their children.	Nil
Q7. Changes in alcohol use	Nil	Nil
Q8. Co-morbidity at post- deployment	Compared to those who had no co-morbidities at post- deployment, those with one, two or three psychological conditions were significantly more likely to perceive that their military career had a negative impact on their children.	Compared to those who had no co-morbidities at post- deployment, those with one or two psychological conditions were significantly more likely to perceive problems with the children while on deployment.

18.5 Discussion

This chapter investigated two factors which related to the children of deployed personnel. First, the participant was asked about any impact their military career may have had on their children. More than half of all parents who completed the self-report questionnaire reported that their military career had a negative impact on their children at post-deployment. Second, the chapter also presented findings pertaining

to whether there had been any problems with their children while the participant was on deployment. While the majority of parents did not believe there were any notable concerns, 112 out of the 510 parents who answered this question at post-deployment did report that they had experienced problems with their children during their most recent deployment.

The recently released Timor-Leste Family Study [17] however, found that for the majority children of personnel deployed to Timor-Leste, there were no adverse outcomes in terms of either behavioural or emotional issues. Reports from the stayat-home partners of deploying personnel who participated in this study suggested that the prevalence of problematic behaviour was low and the level of pro-social behaviour was high, very similar to levels for children in the general Australian population [18].

Participants who reported problems with their children during deployment were also significantly more likely to have experienced combat on a previous deployment. In addition, psychological symptoms were also significantly associated with reporting of problems with children during deployment, as well as a perception that military commitments had a negative impact on their children. It is important to note however, that unlike the Timor-Leste Family Study [17], this study only documented the perceptions of the parent who deployed. It did not independently assess the children or obtain observations from the non-deploying caregiver.

18.5.1 Previous Combat Exposure

Participants in this study who had previously been exposed to combat were significantly more likely to perceive problems with their children, compared to those who had no prior exposure. There are a number of possible reasons for this finding. First, parents who had already experienced combat may be more aware of the potential ramifications of leaving a child for extended periods, and this increased their level of concern. Second, previous encounters with children in Afghanistan could also have led to subtle changes in the parents understanding of their own children. Third, individuals who have been exposed to dangerous environments may also become more vigilant about their own children's welfare.

It is also possible that prior combat may have contributed to an increase in psychological symptoms. Prior research has already shown that military personnel who are exposed to combat trauma on deployment are more likely to experience a deterioration in personal relationships [19, 20]. Rather than combat however, the psychological symptoms associated with combat trauma such as PTSD, are more likely to be the primary contributor to this deterioration.

18.5.2 Psychological Conditions

A number of psychological factors were found to be associated with both the perceived impact of military career on children and the perceived problems with children while on deployment. For example, participants in this study who experienced an increase in PTSD symptoms between pre- and post-deployment were more likely to perceive that there were problems with their children while they were away. In addition, compared to those respondents who had no psychological conditions at post-deployment, those who met the criteria for one or two (but not all three psychological conditions) were significantly more likely to have reported that there were problems with their children their children while on deployment. Finally, compared to those respondents who had no psychological conditions at post-deployment, those who met the orden of the post-deployment, those who had one, two or three were significantly more likely to have reported at post-deployment that their military commitments had a negative impact on their children.

This suggests that experiencing psychological symptoms while on or shortly after deployment was associated with increased worry or concern for their children.

This is not the first study to find an association between psychological symptoms and reduced social health. A study of 468 US army national guards who had recently experienced combat [21] for example, found that symptoms of PTSD negatively impacted on family members. The authors suggested that the tendency for chronic PTSD sufferers to withdraw into themselves may, in particular, contribute to the breakdown in social relationships [22]. This finding is consistent with a qualitative study of peacekeepers who met PTSD criteria, which found that emotional numbing and anger contributed to breakdowns in relationships. Additional symptoms, such as reluctance to discuss the deployment experience with their partners in case they were seen as emotionally vulnerable, further exacerbated the strain on personal relationships [23]. As intimate relationships are known to provide a significant source of social support, the complex impacts of deployment have implications in terms of family functioning.

There have also been a number of studies which have found a direct relationship between the psychological health of parents during deployment and that of their children. For example, analyses of self-reported data from 154 veterans of the Balkan War [24], found that the children of veterans with PTSD were significantly more likely to have developmental, behavioural, and emotional problems, compared to the children of veterans without PTSD. Al-Turkait et al [25] demonstrated that both the father's PTSD status and the mother's psychological and social status were significantly associated with behavioural problems in their children. Flake et al [26] also found that the psychosocial functioning of children during a deployment was associated with the level of stress experienced by the parent at home.

18.6 Summary

This study has shown that the majority of military parents did not perceive problems with their children while they were on deployment. However, those exposed to previous combat, and those with increases in PTSD symptoms between pre- and post-deployment were significantly more likely to perceive problems with their children. There are a number of possible explanations for these associations, including that people with previous combat exposure may have increased psychological symptoms, which in turn could impact on the parent-child relationship. Teasing out these relationships (which was not done in the analyses presented here) is an important direction for the future.

Importantly, more than half of parents perceived that their military commitments had a negative impact on their children. The change in PTSD symptoms between preand post-deployment, and the presence of psychological conditions at postdeployment were associated with a greater likelihood of perceiving this negative impact. While poor psychological health may be associated with a bias to perceive other aspects of one's life and relationships negatively, there is also evidence from previous research that PTSD symptoms can have a more direct negative impact on family functioning.

The willingness of parents to express their concerns about the impact of deployment on children provides a potentially important avenue for intervention in the postdeployment environment. In general parents are often more willing to seek care for a child than for their own psychological distress. A clinical service with a child focus has the potential to decrease the barriers to care in the post-deployment environment and this approach has been utilised in the US Marines.

The next section is entitled **Identifying Potential Risk Markers.** It focuses on three measures which in the future may prove useful as clinical screens for the risk of future morbidity and mortality. Immediately following this chapter is a short introduction to the theory that has formed the basis for the development of potential risk markers. Specific chapters within this section are:

- Chapter Nineteen qEEG
- Chapter Twenty Working Memory
- Chapter Twenty One Allostatic Load

The final chapter in this report summarises and discusses the findings from the MEAO Prospective Study.

18.7 Further Analysis

The initial analyses presented in this chapter would benefit from an investigation of the moderators and mediators which may have impacted on the associations that were identified.

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Section Four - Introduction to Identifying Potential Risk Markers

Various physical and psychiatric conditions, including depression, anxiety and PTSD have been shown to be highly prevalent in military populations [1]. Unique exposures (e.g., deployment, combat) that military personnel may experience during their tenure are likely to contribute to these increases [1, 2]. Yet many disorders do not develop until months or even years following deployment [3]. This section begins to consider the potential for neurocognitive assessments and/or the allostatic load to act as risk markers of future morbidity or mortality. The relationship between these two dimensions of adaptation is that they both reflect indices of arousal and reflect the individual's sifts in capacity to respond in a flexible manner to future stresses.

Neurocognitive Assessments

Neurocognitive changes in the absence of diagnosed disorder among deployed military personnel have, however, been found [4], suggesting that the stress which can eventually lead to these disorders, may have more immediate impact on neurocognitive functioning. Until recently, however, there have been limited methods to objectively measure the impact of this stress. Historically the identification of psychological stress has largely been based on the individual's subjective experience. More recently electrophysiological research has yielded valuable insights into the neurophysiological underpinnings of psychopathology [5].

With the advent of advanced computerized qEEG techniques, for example, researchers have made significant advances in identifying specific electrophysiological profiles associated with various psychopathologies. As such, differential patterns of cortical brain activity measured at the scalp via gEEG may provide objectively observable markers for common psychiatric disorders such as depression [6], anxiety [7] and post-traumatic stress disorder [8] which may be more common in military populations. The first chapter in this section therefore focuses on the changing patterns of cortical brain activity between pre- and post-deployment, as measured via gEEG.

The second chapter in this section focuses on working memory which is one of the most important neurocognitive functions. The ability of the brain to hold information in mind and flexibly manipulate that information is considered a defining characteristic of human cognition and is critical to human survival. This capacity is the substrate upon which all other higher cognitive functions are subserved. Working memory provides the primary mechanism for the maintenance, elaboration and manipulation of mental representations, and therefore underpins virtually all conscious cognitive processes including reasoning and problem solving [9]. A substantial body of research has now demonstrated that abnormalities of working memory underpin psychiatric disorders, particularly PTSD [10]. Hence, the ability of an individual to process and integrate a highly threatening and traumatic experience is particularly dependent upon adequate working memory systems.

In addition to qEEG and working memory, a number of other paradigms were also assessed by the MEAO Prospective Study in order to understand changes to neurocognitive functioning between pre- and post-deployment. These paradigms included response inhibition, startle and emotional processing. However, the analyses and presentation of these results were beyond the scope of this report.

Allostasis and the Allostatic Load Model

Allostasis recognises that physiological states change over time, and that both physical and psychological stressors elicit various physiological reactions in an attempt to return to what is the steady state at that particular time [11]. Repeated action by physiological systems in an effort to deal with physical and/or psychological stressors [11] produces continuous wear and tear across multiple physiological systems, contributing to a person's health risk [12].

The allostatic load model has been used to refocus the stress disease literature, emphasising that multiple biological systems are vulnerable to a temporal cascade of dysregulation [13]. Progressive dysregulation leads to the emergence of a range of disease trajectories that arise from this common pathway. This approach provides a broader construct than traditional detection methods used in biomedical practice for understanding how repeated challenges from the environment lead to increasingly maladaptive disruptions of physiological systems.

The following chapters in this section focus on identifying potential risk markers for changes to health outcomes of interest.

- Chapter Nineteen **qEEG**
- Chapter Twenty Working Memory
- Chapter Twenty One Allostatic Load

After providing a short introduction, each chapter describes the measure/s used to identify change, before presenting the primary results. Each chapter concludes with a discussion of these results in relation to the current literature.

The final chapter in this report presents the **Conclusions and Limitations** of the MEAO Prospective Study.

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Chapter Nineteen – Quantitative Electroencephalography (qEEG)

Key Points

- 1. The overall pattern of findings suggests that **initial deployment and combat exposure may have lasting impacts on resting brain states**.
- 2. There is some evidence to suggest that these impacts may have **flow-on effects in relation to subsequent deployments** (a sensitising effect).
- 3. The **number of prior deployments** and total months deployed in last three years was associated with reduced occipital alpha-2 power (eyes closed). In particular, there was a marked reduction post-deployment in those participants who had no prior deployments. These findings suggest cortical hyperarousal as a consequence of deployment
- 4. The **length of time spent on the most recent deployment** was associated with increased frontal theta power, suggesting disruption of working memory function.
- 5. **Prior combat exposure** was associated with increased frontal and increased centroparietal alpha (eyes open), and reduced beta in frontal, central and centroparietal regions. These findings are further suggestive of diminished attentional processing capacity.

This chapter presents and discusses the findings relating to changes between preand post-deployment for quantitative electroencephalography (qEEG) measures of resting state brain function. The chapter begins by introducing the utility of the qEEG methodology as an objective measure of brain function that may capture changes in resting state brain function in deployed personnel. Analyses relating to the changes between pre- and post-deployment for cortical brain activity as measured by qEEG, are then presented. The chapter concludes by discussing the primary findings pertaining to changes in cortical brain activity.

19.1 Introduction

With recent development in advanced computerized qEEG techniques, there have been significant gains in identifying specific electrophysiological profiles associated with various psychopathologies [1]. Differential patterns of cortical brain activity measured at the scalp via qEEG may eventually provide objectively observable markers for common psychiatric disorders such as depression, anxiety and PTSD. Examining qEEG in soldiers prior to and following deployment therefore provides an opportunity to examine the way that resting state oscillatory brain activity is modified by stress exposure. qEEG is one objective measure that could be used to identify changes resulting from stress exposures which may lead to future psychological disorders. While it is expected that only a small percentage of soldiers involved in the MEAO Prospective study will develop new psychiatric disorders in the immediate aftermath of their deployment, it is still important to ascertain the characteristics of changes in qEEG associated with these disorders. Depression, for example, is believed to be linked to reduced activity in various brain regions associated with the processing of positive emotion [2-4]. Reduced activity in certain areas may underpin depressive symptoms including low energy, fatigue symptoms, and cognitive deficits [5]. Interestingly, diffuse *increases* in cortical activity have also been found in some depressed groups [6] which may be associated with high incidence of co-morbid anxiety symptoms in depression (e.g. agitation and psychomotor disturbance).

Increasing attention has also been given to the neuropathology of PTSD, in part due to its high prevalence rate in certain populations including combat veterans [7]. Compared to healthy controls, PTSD groups have been found to exhibit increased central theta band activity which may reflect dysfunction of sub-cortical limbic structures [8]. Similarly, increased beta power over various sites has also been found in PTSD groups, and is thought to be linked to hyperarousal symptoms (e.g. restlessness, sleep disturbance etc.) [8].

19.2 Measures

qEEG is a method for measuring brain electrical activity that involves high-powered computer analytic systems to deconstruct signals from multi-channel EEG into power frequency spectra. Spectral analysis of qEEG has been used to define a set of basic EEG rhythms, which are associated with certain physiological and functional states. In general terms there are four primary spectral wavebands which are extracted from EEG recordings, namely alpha, beta, theta and delta frequencies (Table 19.1).

Table 19.1: Cognitive Wavebands Pertinent to the Neurocognitive Analyses

Alpha rhythms represent oscillatory neural activity in the range 8 to 13 Hz and tend to predominate in posterior regions (occipital and parietal areas), in primary and secondary sensory areas of the brain. During quiet wakefulness, the alpha rhythm is generally associated with a resting or idle state of consciousness, and is enhanced during eyes-closed conditions. In comparison, alpha rhythms tend to be suppressed when eyes are opened. Therefore, as cortical activity increases alpha power decreases [9]. Abnormal levels and distributions of alpha rhythms have been found to be associated with various psychopathologies, most prominently depression and anxiety disorders [5, 10-12].

The beta waveband includes spectral frequencies between 14 to 30Hz. Beta waves are high frequency, and have been associated with cortical excitability. They tend to be found predominantly in frontal or central regions. Studies have found a positive correlation between beta power and underlying cortical metabolism, supporting the suggestion that this frequency band is associated with increased cortical activity. The overabundance of beta activity has been found to be associated with certain forms of psychopathology, specifically anxiety disorders [9].

The theta waveband includes spectral frequencies between 4 to 7.5 Hz. Theta is considered a slow-wave, and is commonly observed in deep relaxation or sleep. However, in wakeful EEG recordings, theta power has been found to be associated with attentional and memory processes, which are associated with the hippocampal theta rhythm, believed to be important to memory encoding and retrieval. Theta power is suggested to reflect the functional integrity of sub-cortical structures such as the hippocampus, which is vital in memory function [9]. Theta has also been associated with increased metabolic activity in the medial frontal area and the anterior cingulate. It is maximal at Fz, is synchronised in response to behaviour related to important events, and associated with recalling from memory and encoding memory traces. Furthermore, the amount of frontline theta can correlate with anxiety scores [9].

The delta waveband encompasses spectral frequencies between 1 to 4Hz. Delta is the slowest waveband with the highest amplitudes in the spectrum, and is commonly observed in deep sleep but is sometimes also present in wakeful EEG recordings [9]. Delta rhythms, generated in the thalamus, appear in the EEG when cortical areas are disconnected from the thalamic nuclei. It is usually only present during sleep, particularly the slow wave phase. The activity can be generated from either the thalamus or the cortex. Due to the relationship of delta activity with sleep, recordings in this frequency band were not of interest in the current study.

19.2.1 Procedure for EEG Acquisition

Participants were seated in a sound and light attenuated room during the collection of electroencephalographic (EEG) data. EEG was acquired using a Quikcap and 40 channel NuAmps with electrodes located according to the or 10/20 international system from the following 26 scalp sites: Fp1, Fp2, F7, F3, Fz, F4, F8, FC3, FCz, FC4, T3, C3, Cz, C4, T4, CP3, CPz, CP4, T5, P3, Pz, P4, T6, O1, Oz and O2 (Figure 19.1).



Figure 19.1: Fitting of QuickCap in preparation for neurocognitive acquisitions

Horizontal eye movements were recorded from electrodes placed 1.5cm lateral to the outer canthus of each eye. Vertical eye movements were recorded with electrodes placed 3mm above the middle of the left eyebrow and 1.5cm below the middle of the left bottom eye-lid. Electrode impedance was generally maintained below 5 kOhms. EEG data were acquired using a continuous acquisition system, with a sample rate of 500Hz with a 22-bit analog-to-digital converter (NuAmps). EEG data were recorded relative to the virtual ground and re-referenced off-line to linked mastoids. EEG data were collected during both resting and task activation paradigms.

19.2.2 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **the number of prior deployments** and changes in qEEG measures between pre- and post-deployment?
- 2. Is there an association between the **time away in the previous three years** and changes in qEEG outcome measures between pre- and post-deployment?
- 3. Is there an association between **prior combat exposure** and changes in qEEG measures between pre- and post-deployment?
- 4. Is there an association between **length of most recent deployment** and changes in qEEG measures between pre- and post-deployment?

19.2.3 Sample Sizes

The total sample size used **to identify change between pre- and post-deployment** for the qEEG measures was 170. Of the 278 participants who completed a predeployment neurocognitive assessment, 170 of these also completed postdeployment neurocognitive assessment. Data analyses presented in this chapter are based only on data from participants who completed both pre- and post-deployment neurocognitive assessments.

There is, however, considerable variation to the sample sizes available for each analysis. This is a common occurrence in the collection and analysis of multichannel EEG. Data was excluded as a result of:

- measurement noise due to bad electrodes,
- electrodes that showed biologically implausible values (> 3SDs from the mean), which were set to missing values and therefore excluded from individual analyses; and
- survey data that were missing for particular analyses.

In cases where data were excluded, sample sizes are noted immediately prior to the presentation of each result. It is important to note that the exclusion of a particular electrode site for an individual did not preclude data from other electrodes sites from that participant being included in further analyses.

19.2.4 Data Analysis

Average power spectra were computed for the eyes open and eyes closed conditions. The two minutes of EEG in each condition were first divided into adjacent intervals of four seconds. Power spectral analysis was performed on each four second interval by first applying a Welch window to the data and then performing a Fast Fourier Transform (FFT). The resulting power spectra were then averaged for each electrode position for each condition (eyes open, eyes closed) over the following frequency bands: delta (1.5 - 3.5 Hz), theta (4 - 7.5 Hz), theta (4 - 5 Hz),

theta2 (5 – 7.5 Hz), alpha (8 – 13 Hz), alpha1 (8 – 11 Hz), alpha2 (11 – 13 Hz), beta (14.5 – 30 Hz), beta1 (14.5 – 20 Hz), beta2 (20 – 25 Hz) and beta3 (25 – 30 Hz). Results are reported in power spectral density amplitude for each frequency band and sub-band.

A mixed model for repeated measures was used to analyse each qEEG band and sub-band for all 26 electrode sites (Fp1, Fp2, F7, F3, Fz, F4, F8,FC3, FCz, FC4, T3, C3, Cz, C4, T4, P3, CPz, CP4, T5, P3, Pz P4, T6, O1, Oz, O2). This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post-deployment) and their interaction(s) are included as fixed effects in the model.

To control for outliers, all qEEG variables were truncated to a cut-off of three standard deviations prior to analysis, such that data excluding this threshold were set to missing values.

It is important to note that the results presented in this chapter are preliminary. Given the large number of variables the results should be considered with some caution as no adjustment was made for multiple testing. Ideally, a more robust analysis is required in order to model both the spatial (26 sites for each subject) and temporal (pre- and post-deployment) nature of the data.

19.3 Results

19.3.1 Number of Prior Deployments

For the purposes of analysing the neurocognitive assessment data, the number of prior deployments was categorised into the following groups:

- No prior deployments
- 1 2 prior deployments
- 3 4 prior deployments
- 5+ prior deployments

Significant interactions between time (pre- and post-deployment) and number of prior deployments were observed in the alpha-2 band (eyes closed) at electrode sites Oz and O2. Results are presented for one representative electrode site, Oz in the occipital region only. A significant interaction was found (p=0.025) between time (pre- and post-deployment) and number of prior deployments in the alpha-2 band at electrode Oz.

The mean changes in alpha-2 power at electrode site Oz between pre- and postdeployment for the different numbers of prior deployments are presented in Table 19.2.
Number of prior deployments	N	Pre-deployment Post-deployment (95% CI) (95% CI)		Change (95% Cl)
None	29	9.229 5.614 (7.019, 11.438) (4.174, 7.054)		-3.615 (-5.420, -1.811)
1-2 times	50	6.284 (4.602, 7.967)	5.071 (3.974, 6.167)	-1.213 (-2.588, 0.160)
3-4 times	22	5.742 5.818 (3.205, 8.279) (4.165, 7.472)		0.076 (-1.995, 2.148)
5+ times	27	4.509 (2.219, 6.799)	4.116 (2.624, 5.609)	-0.393 (-2.263, 1.477)

Table 19.2: Mean (95% CI) power spectral density for the alpha-2 band at site Oz during the resting eyes closed condition grouped by number of prior deployments.

At pre-deployment individuals with 3 to 4 previous deployments (p=0.008) and 5 or more previous deployments (p=0.004) showed significantly reduced occipital alpha-2 power, on average, relative to those with no prior deployments.

Between pre- and post-deployment, personnel with no previous deployment experience exhibited the greatest reduction, on average, in occipital alpha-2 power (eyes closed) compared to those with 3 to 4 (p=0.004) and 5 or more deployments (p=0.034). Similarly, the reduction in alpha-2 power from pre- to post-deployment for the group with 1 to 2 prior deployments was greater than for the group with 3 to 4 prior deployments (p=0.048).

These findings reflect the stable but reduced pattern of occipital alpha-2 power that is observed in groups with greater deployment experiences. The significance effect of number of prior deployments is shown in Figure 19.2.



Figure 19.2: Plot of mean power spectral density (μV^2) for the alpha-2 band at site Oz (eyes closed) for each group (number of prior deployments) at pre- and post-deployment.

19.3.2 Total Time on Deployment in Previous Three Years

Due to there being few participants who had deployed for more than 12 months three categories were considered in the analysis for total time on deployment (None, 1-6 months, 7+ months).

Significant interactions between time (pre- and post-deployment) and total time on prior deployments were observed in the alpha-2 band (eyes closed) at electrode sites Oz and O2. Results are presented for one representative electrode site, Oz in the occipital region. The significant interaction (p=0.046) between time (pre-, post-deployment) and the total time on deployment in previous three years was observed at electrode site Oz.

The mean changes to alpha-2 power at electrode site Oz between pre- and postdeployment for the total time on deployment in previous three years are presented in Table 19.3.

Total time on prior deployments	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
None	28	9.147	5.550	-3.597
		(6.976, 11.318)	(4.071, 7.028)	(-5.356, -1.838)
1-6 months	29	4.868	4.954	0.086
		(2.734, 7.001)	(3.501, 6.407)	(-1.642, 1.814)
7+ months	65	5.540	4.860	-0.680
		(4.115, 6.965)	(3.889, 5.830)	(-1.834, 0.475)

Table 19.3: Mean (95% CI) power spectral density for the alpha-2 band at site Oz during the restingEyes Closed condition grouped by total time on deployment in previous three years.

At pre-deployment individuals who have previously deployed for 1 to 6 months in the last 3 years (p=0.018) and 7 or more months (p=0.017), showed significantly reduced occipital alpha-2 power, on average, relative to those who had never been deployed. The levels of alpha-2 power for personnel with 1 to 6 months and 7 or more months prior deployment experience, were comparable at pre-deployment.

The change (reduction) in occipital alpha-2 power between pre- and post-deployment for those with no previous time (months) on deployment was significantly greater than in groups with 1 to 6 months (p=0.027) and 7 or more months experience on deployment (p=0.026). There was no significant change in occipital alpha-2 power between pre- and post-deployment between those with 1 to 6 months and 7 or more months prior deployment experience, reflecting the stable but reduced pattern of occipital alpha-2 power observed in groups with greater deployment experiences (Figure 19.3).



Figure 19.3: Plot of mean power spectral density (μ V2) for the alpha-2 band at site Oz (eyes closed) for each group (time in months on prior deployments in the last three years) at pre- and post-deployment.

19.3.3 Previous Combat Exposure

19.3.3.1 Centroparietal alpha

There was a significant interaction (p=0.015) between time (pre-, post-deployment) and previous combat exposure in the alpha band (eyes open) in the centroparietal region (CPz). For simplicity, results are presented for one representative electrode site, CPz, although this pattern was present in other neighbouring electrode sites: CP3, CP4, Cz C3. The electrodes showing this pattern are depicted in Figure 19.4.



Figure 19.4. Depiction of significant electrodes on a schematic representation of the scalp for centroparietal alpha (eyes open).

The mean changes to centroparietal alpha power at electrode site CPz between preand post-deployment for participants with and without prior combat exposure are presented in Table 19.4.

Previous combat	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
No	96	15.082 (12.750, 17.413)	16.809 (14.042, 19.577)	1.728 (-0.098, 3.553)
Yes	52	14.409 (11.241, 17.577)	18.384 (14.624, 22.145)	3.975 (1.494, 6.456)

 Table 19.4: Mean (95% CI) power spectral density for the alpha band at site CPz during the resting

 Eyes Open condition grouped by previous combat exposure.

As presented in Table 19.4, personnel with and without previous combat exposure showed comparable levels of centroparietal alpha power (eyes open) at predeployment. Although both groups (with and without prior combat) showed increases in alpha power in this region, the increase in alpha power between pre- and post-deployment was significantly greater in those with previous combat exposure (p=0.015) compared to those without (Figure 19.5).



Figure 19.5: Plot of mean power spectral density (μV^2) for the alpha band at site CPz (eyes open) for each group (previous combat exposure) at pre- and post-deployment.

19.3.3.2 Frontal alpha

There was a significant interaction (p=0.037) between time (pre-, post-deployment) and previous combat exposure in the alpha band (eyes open) in the frontal regions (F3). Results are presented for one representative electrode site, F3, although this similar pattern was present in sites Fp1, Fp2, F7, F3, Fz, FC3. The electrodes showing this similar pattern are depicted in Figure 19.6.



Figure 19.6: Depiction of significant electrodes on a schematic representation of the scalp and ... for frontal alpha (eyes open).

The mean changes to frontal alpha power at electrode site F3 between pre- and post-deployment for participants with and without prior combat exposure are presented in Table 19.5.

Previous combat	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
No	96	9.656	10.147	0.490
		(8.566, 10.746)	(8.892, 11.401)	(-0.387, 1.367)
Yes	52	8.094	9.665	1.571
		(6.613 <i>,</i> 9.575)	(7.961, 11.370)	(0.380, 2.763)

 Table 19.5: Mean (95% CI) power spectral density for the alpha band at site F3 during the resting eyes open condition grouped by previous combat exposure.

As presented in Table 19.5, personnel with and without previous combat exposure showed comparable levels of frontal alpha power (eyes open) at pre-deployment. The combat exposed group showed a significant greater increase in alpha power from pre- to post-deployment (p=0.01) than the non-exposed group (Figure 19.7).



Figure 19.7: Plot of mean power spectral density (μ V2) for the alpha band at site F3 (eyes open) for each group (previous combat exposure) at pre- and post-deployment.

19.3.3.3 Beta

Significant interactions were found between time (pre-, post-deployment) and prior combat exposure in the beta band at frontal and central and centroparietal electrode sites (F7, F3, F8, FC4, C4, CP3, CP4) (Figure 19.8). Results are presented for one representative electrode site, C4 in the central region (p=0.017).



Figure 19.8: Depiction of significant electrodes on a schematic representation of the scalp and ... for the beta band (eyes closed).

The mean changes to beta power at electrode site C4, for personnel with and without prior combat exposure are presented in Table 19.6.

Previous combat	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
Νο	97	10.609 (9.669, 11.550)	9.671 (8.828, 10.513)	-0.939 (-1.661 <i>,</i> -0.216)
Yes	50	8.779 (7.469, 10.089)	8.902 (7.728, 10.076)	0.123 (-0.883, 1.129)

Table 19.6: Mean (95% CI) power spectral density for the beta band at site C4 during the resting eyes closed condition grouped by previous combat exposure.

As presented in Table 19.6, personnel with previous combat exposure had significantly lower beta power at pre-deployment, relative to those with no previous combat exposure (p=0.028). This reduction was stable over time, and the combat-exposed group did not show any significant changes between pre- and post-deployment. In comparison, the group without previous combat exposure showed a significant reduction in beta power between pre- and post-deployment (p=0.005) (Figure 19.9).



Figure 19.9: Plot of mean power spectral density (μV^2) for the beta band at site C4 (eyes closed) for each group (previous combat exposure) at pre- and post-deployment.

19.3.4 Length of Most Recent Deployment

Due to the small number of participant having deployed for 9-12 months, three categories were considered in the analysis for length of most recent deployment (≤ 5 months, 6 or 7 months, 8-12 months).

Significant interactions were observed in frontal regions between time (pre-, postdeployment) and the length of time (months) spent on the most recent deployment, in the theta band (eyes open) at prefrontal electrode sites Fp1, Fp2 and in the left frontal region in F3 and F7. Results are presented for one representative electrode site, Fp1 in the left prefrontal region (Figure 19.10).



Figure 19.10: Depiction of significant electrodes on a schematic representation of the scalp and ... for frontal theta (eyes open).

A significant interaction (p=0.022) was found between time (pre- to post-deployment) and length of most recent deployment in the theta band (eyes open) within the frontal region. The mean changes to theta band at the Fp1 site between pre- and post-deployment, for each length of time on most recent deployment are presented in Table 19.7.

Length of recent deployment (months)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% Cl)
≤ 5months	58	5.899 (5.181, 6.618)	7.245 (6.502, 7.987)	1.345 (0.600, 2.091)
6 or 7 months	34	6.561 (5.577, 7.454)	6.989 (6.019, 7.958)	0.473 (-0.500, 1.447)
8 - 12 months	58	7.148 (6.429, 7.866)	7.157 (6.415, 7.900)	0.009 (-0.736, 0.755)

 Table 19.7: Mean (95% CI) power spectral density for the theta band at site Fp1 during the resting

 Eyes Open condition grouped by time (month) on most recent deployment.

At pre-deployment, personnel who were deployed for 8 to 12 months showed the highest levels of frontal theta (p=0.017), relative to personnel who had been

deployed for 5 months or less, who had the lowest levels of frontal theta power at pre-deployment.

The change in frontal theta power between pre- and post-deployment indicated that personnel deployed for 5 months or less showed the greatest increase in frontal theta power (p<0.0001) compared to those deployed for 8 to 12 months. No significant increase was found for those deployed for 6 to 7 months or 8 to 12 months, reflecting the stable but increased pattern of frontal theta power observed in personnel with greater deployment experiences (Figure 19.11).



Figure 19.11: Plot of mean power spectral density (μV^2) for the theta band at site Fp1 (eyes open) for each group (length of time in months on most recent deployment) at pre- and post-deployment.

19.4 Summary of Results

Table 19.8 summarises the key findings presented in this results section. Following the summary of results is a discussion section which draws together the findings presented above with reference to literature which has already been published.

Question	Significant Associations
Q1. Association between the number of prior deployments and changes in gEEC	Participants with no prior deployment experiences had a significantly greater reduction in occipital alpha-2 power (eyes closed) than for those who had previously deployed at least once, at the time of completing the pre-deployment measure.
measures	Participants who had previously deployed 3 to 4 times and 5 or more times showed no significant changes in occipital alpha-2 power (eyes closed), on average between pre- and post-deployment.
Q2. Association between the time away in last 3 years and changes in qEEG measures	Participants with no prior time on deployment had a statistically significantly greater reduction in occipital alpha-2 power (eyes closed) between pre- and post-deployment than those who reported being away on previous deployments for 1 to 6 months and 7 or more months.
	Participants who had been away for 1 to 6 months and 7 or more months showed no significant changes in occipital alpha-2 power (eyes closed), on average between pre- and post-deployment.
Q3. Association between prior combat and changes in qEEG measures	Participants with previous combat exposure had a statistically significant greater increase in centroparietal alpha power (eyes open) between pre- and post-deployment, in comparison to those who did not report prior combat exposure.
	Participants with previous combat exposure had a statistically significant greater increase in frontal alpha power (eyes open) from pre- to post-deployment, in comparison to those who did not report prior combat experience.
	Participants with previous combat exposure had a statistically significant lower beta power at pre-deployment, relative to those with no previous combat exposure.
	Participants with previous combat exposure showed no significant changes in beta power, on average between pre- and post- deployment.
Q4. Association between length of most recent deployment and changes in qEEG	Participants who had deployed for 5 months or fewer showed a statistically significantly greater increase in frontal theta power compared to those who deployed for 8 to 12 months.
measures	No significant increase was found for those deployed for 6 to 7 months or 8 to 12 months.

Table 19.8: Summary of key findings presented in this chapter

19.5 Discussion

A number of significant changes in resting qEEG were identified in these analyses, and were found to be associated with specific aspects of military service. These findings provide important insights into the hyperarousal that veterans commonly report following deployment. Importantly, these shifts in arousal are observable by an objective methodology that does not depend on self-report data. While these findings are technical in detail, they provide evidence about how neurophysiological assessments may provide valuable information into the effects of deployment. The significance and meaning of these findings should be considered as a preliminary exploration of these phenomena as similar research has not previously been conducted in a non clinical sample in the context of such major stress exposures.

19.5.1 Reduced Occipital Alpha Power

A reduction in alpha-2 power (eyes closed) in the occipital region was found to be associated with two prior deployment variables. First, the **number of prior deployments** and second, **total months deployed in previous three years**. This **reduction in alpha power** reflects an increase in underlying cortical activation, which is not normally associated with a resting state (i.e. eyes closed) [9].

Also at pre-deployment assessment, these findings suggested significantly increased cortical arousal for those participants who had previously deployed, in comparison to those who reported no prior deployments. It was also the case that the number of prior deployments tended to influence this increase. For example, those participants who had the greatest number of prior deployments (5 or more) had the lowest alpha power at pre-deployment, suggesting the persistent and increasing cortical hyperarousal. Results also suggest that increases in cortical arousal persist with subsequent deployments.

In comparison to those who had previously deployed, those with no prior deployments had greater reductions in alpha power, suggesting larger shifts in cortical arousal. This finding indicates that increased hyper-alertness can occur after the first deployment. One potential explanation for this statistically significant finding is that deployment impacts upon the capacity of the visual system to enter idling mode, which is the expected resting state.

The apparent lack of difference between personnel who had previously deployed for 1 to 6 months and those deployed for 7 or more months suggests that these results were not dependent on the duration or time spent on prior deployments. Instead, findings suggest that it is more likely that any deployment experience, no matter the length of time, is associated with increased cortical arousal. However this question requires further investigation.

Reductions in alpha power have also been observed in individuals with PTSD [13] and a pervasive reduction in alpha activity over the frontal, temporal, central and occipital sites has specifically been found in combat veterans with PTSD [14]. As the generation of alpha rhythms are primarily linked to thalamic oscillations [15, 16], it has been suggested that abnormalities in this critical subcortical structure may underlie the sensory dys-regulation and attention deficits which are associated with PTSD [17].

19.5.2 Increased Centroparietal Alpha

Prior combat exposure was associated with *increased centroparietal alpha* (eyes open). A significantly greater increase in alpha rhythm between pre- and post-deployment was found for participants who had reported prior combat exposure, in

comparison to those who did not report any prior combat exposure at predeployment. Increased alpha power is associated with a decrease in cortical engagement [9]. This is not normally associated with the alert state (eyes open) as alpha is generally suppressed when attention is fixed on the environment.

This finding may indicate that participants who have previously experienced combat may have significantly decreased cortical activity in the centroparietal region between pre- and post-deployment. In particular, they suggest a progressive disruption of working memory function compatible with the concepts of sensitization and kindling [18].

19.5.3 Increased frontal alpha

Prior combat exposure was also associated with significantly *increased frontal alpha* (eyes open) between pre- and post-deployment, in comparison to no prior combat exposure. This finding suggests that combat exposure may lead individuals to a greater increase in frontal alpha power which is correlated with clinical arousal as measured by the CAPS [13].

While alpha rhythms are not typically associated with frontal regions as alpha power values tend to be small [9], frontally reduced alpha observed in groups diagnosed with PTSD has previously been shown to be associated with attentional dys-regulation and abnormalities in sub-cortical thalamic structures [15, 16]. In addition, abnormal distribution of frontal alpha power has been widely associated with dys-regulation of emotion processing systems which may be related to affective symptoms in psychopathologies such as depression and anxiety based disorders [19-21]. These findings require further exploration but highlight the cumulative burden of combat exposure on attentional systems.

19.5.4 Reduced Beta

Prior combat exposure was associated with *reduced beta activity* in frontocentral, central and bilateral centroparietal regions. Results showed a significant reduction between pre- to post-deployment in those with no previous combat exposures. In comparison, those with previous combat exposures were found to have already had significantly reduced beta power at pre-deployment, which remained stable between pre- and post-deployment. This finding may suggest that reductions in beta power occur soon after initial combat exposure, and remain stable thereafter. However, this hypothesis requires further longitudinal investigation.

As beta power is closely linked to underlying metabolic activity, these findings suggest that having prior combat exposure may be associated with decreased cortical activity in these regions which are known to associated with a range of executive, motor, and cognitive integration processes [22]. While these findings are consistent with previous observations of reduced beta power in groups with panic disorder [21], other studies involving combat related PTSD groups have observed increases in frontal, central, temporal and occipital beta power. This suggests that elevated beta may also be associated with clinical symptoms such as restlessness, sleep disturbance, attention deficits and nervous arousal [8, 14]. However, the significance of these findings is only likely to become apparent with further follow up of this population.

19.5.5 Increased frontal theta power

The **length of time spent on the most recent deployment** was associated with *increased frontal theta power*. The greatest increase occurred in those with the shortest deployment time (five or fewer months). In comparison, those deployed for longest time (8-12 months), already showed an increased theta at pre-deployment,

and that increase proved to be stable between pre- and post-deployment. Therefore, at post-deployment, increased theta was present in all groups at comparable levels.

The current finding of increased frontal theta activity associated with time on deployment is suggestive of a change in executive function that, in turn, may be indicative of deficits in attentional control and affect regulation systems [23]. In particular, a number of studies have found that theta power is associated with psychological disorders such as PTSD. While qEEG does not measure the function of precise neural regions, hippocampal function is thought to be related to theta activity [9] and this region is of interest in PTSD[24] [25].

Whilst the functional significance of increased frontal theta power remains unclear, it may possibly reflect subcortical dysfunction of the hippocampus and/or changes in the activity of the medial prefrontal and anterior cingulate region [25,26]. These data demonstrate that time on deployment has a significant impact on resting frontal theta activity indicative in shifts in the related activity of the networks that underpin this activity.

19.6 Summary

The overall pattern of findings suggests that initial deployment and combat exposure may have lasting impacts on resting brain states. Furthermore, there is some evidence to suggest that these impacts may have flow-on effects in relation to subsequent deployments (a sensitising effect). Importantly, the cognitive functions these resting brain states are hypothesised to reflect have been implicated in PTSD and other psychiatric conditions that are also likely to occur in deployed and combat exposed personnel. Whether these differences in resting brain states were associated with current and possibly future psychological symptoms, is a question that demands further exploration.

Chapter Twenty will now focus on findings from the **working memory** analysis which is the other neurocognitive paradigm presented in this report. Once again, after providing a short introduction, an explanation of the measure is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature.

The final two chapters in this report are:

- Allostatic Load (Chapter Twenty One)
- Conclusions and Limitations (Chapter Twenty Two)

19.7 Further Analysis

The findings presented in this chapter are only preliminary. A more robust analysis is therefore, required in order to model both the spatial (26 sites for each subject) and temporal (pre- and post-deployment) nature of the data. While this unique dataset provides the opportunity to address numerous issues pertinent to the health of deploying populations, there are a number of specific questions which could initially be considered:

• Is lifetime trauma exposure associated with changes in resting qEEG frequency spectra function from pre- to post-deployment?

- Is trauma exposure on current deployment associated with changes in resting qEEG frequency spectra from pre- to post-deployment?
- Is there an association between changes in psychological distress (as measured by the K10) from pre- to post-deployment and changes in resting qEEG frequency spectra from pre- to post-deployment?
- Is there an association between change in PCL scores from pre- to postdeployment and changes in resting qEEG frequency spectra from pre- to postdeployment?
- Is there an association between lifetime mTBI reported at pre-deployment and resting qEEG frequency spectra at pre-deployment?
- Is a new mTBI reported at post-deployment associated with changes in resting qEEG frequency spectra from pre- to post-deployment?

In addition, a number of other paradigms were also assessed by the MEAO Prospective Study in order to understand changes to neurocognitive functioning between pre- and post-deployment. These paradigms which include response inhibition, startle and emotional processing, require extensive analyses.

19.8 References

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Chapter Twenty – Working Memory

Key Points

- 1. **Analyses of working memory were limited** to the event related component P300 (P3wm).
- 2. Changes between pre- and post-deployment for the P3wm were related **to both prior and current deployment** related factors.
- 3. Findings suggested that changes in the amplitude and/or latency of the P3wm component were associated with:
 - five or more prior deployments,
 - prior combat experience,
 - being away for 8 to 12 months on the most current deployment; and
 - traumatic deployment exposures.

This chapter presents and discusses the findings relating to changes between preand post-deployment for working memory function, measured with one of the four event related potential (ERP) paradigms employed in the MEAO Prospective Study. The chapter begins by discussing the literature relating to the working memory paradigm and providing an overview of how it was measured in this study. Analyses relating to the changes between pre- and post-deployment for cortical brain activity measured by the working memory paradigm are then presented. The chapter concludes by discussing the primary findings pertaining to changes in cortical brain activity.

20.1 Introduction

Working memory has been described in a variety of ways, however prevailing models tend to consider working memory as a limited-capacity cognitive system, used for the temporary storage and manipulation of information over a relatively short period of time. These processes are considered essential to subserve higher-order executive functions (e.g. planning, problem-solving, comprehension and reasoning) [1-3].

Working memory is of particular interest to military populations as military-specific factors such as deployment have been found to be associated with deficits in areas of cognitive functioning [4]. These include sustained attention, verbal learning and visual-spatial memory, processes that are all subserved by working memory. Disturbances in cognitive function are also associated with a range of psychiatric disorders which tend to be prevalent in military populations, including depression, panic disorder, generalised anxiety disorder and PTSD [5, 6]. Working memory may also be compromised in people who have suffered an mTBI [7]. Significantly, even in the absence of any psychiatric disorder, there is evidence that experiences such as military deployment have the potential to disrupt information processing [4].

Importantly, in contrast to many behavioural performance-based neuropsychological protocols that have previously been used to assess cognitive function in both general and military populations, studies such as the MEAO Prospective Study which have utilised event related potential measures, have found observable electrophysiological differences when comparing pathology groups to healthy controls [3]. Subtle neurophysiological deficits may exist when neuropsychological test performance does not indicate any abnormalities [8], so a more sophisticated, objective methodology such as that used by the MEAO Prospective Study is needed to assess such cognitive functioning. Studies using these types of methodologies are beginning to identify disturbances in working memory that are thought to play a key role in the aetiology, symptomology and maintenance of many mental health disorders [3, 5]. However, no study to date has examined brain function pre- and post-deployment in relation to working memory systems using objective event-related potential measures. The use of this paradigm in a group of troops prior to and following deployment provides a unique opportunity to better define the effects of stress on these working memory systems.

20.2 Measures

Many tests have been developed to assess working memory, including the n-back paradigm [2] which was utilised in the neurocognitive acquisition component of the MEAO Prospective Study.

20.2.1 Procedure for Measuring Working Memory

The n-back paradigm involved the participant visually monitoring a series of letter stimuli and responding whenever the stimulus presented is identical to the one presented *n* trials ago (target), where *n* refers to a pre-specified integer; usually 1, 2, or 3 [2]. This variant of the paradigm was a 1-back task, indicating that targets were defined by whether they were identical to the preceding letter (see Figure 20.1). As the sequencing of letters was varied throughout the test, participants were required to continually update working memory representations with the presentation of each new non-target letter stimulus. Thus, non-target stimuli are used to capture cognitive processes associated with the updating of working memory.



Figure 20.1: Example of a 1-back visuo-verbal WM test paradigm.

Participants were seated in a sound and light attenuated room in front of a computer monitor. A series of letters (B, C, D or G) were presented to them one at a time for 200ms in the centre of the screen (Figure 20.1). Participants were instructed to press a button with the index finger of both hands, whenever a letter identical to the one presented previously (1-back) appeared (the "target").

Similar to qEEG paradigm (Chapter Nineteen), continuous EEG was recorded during the performance of the working memory paradigm. Stimulus locked data were then extracted from the ongoing EEG for both target and non-target stimuli and averaged to obtain ERPs.

The key ERP **component of interest in the current study is the P300** which is associated with working memory updating (non-target stimulus), hereafter referred to as the P3wm. The P3wm was specifically chosen because it is thought to reflect cognitive processing [9-12], and more specifically attentional resource allocation and memory updating [13, 14].

In particular, this chapter focuses on the **amplitude** (the degree of response) and **latency** (the time it takes to respond) of this ERP component (Figure 20.2).



Figure 20.2: A schematic representation of an ERP waveform depicting early components (P100, N100, P200) reflecting preconscious stimulus processing and later components (N200, P300) reflecting conscious processing of the stimulus.

20.2.2 Questions to be Addressed

The following questions are addressed in this chapter:

- 1. Is there an association between **the number of prior deployments** and changes in P3wm component between pre- and post-deployment?
- 2. Is there an association between **prior combat exposure** and changes in P3wm component between pre- and post-deployment?
- 3. Is there an association between **length of most recent deployment** and P3wm component between pre- and post-deployment?
- 4. Is there an association between the **number of traumatic deployment experiences** on the most recent deployment and changes in P3wm component between pre- and post-deployment?

20.2.3 Sample Size

The total sample size used **to identify change between pre- and post-deployment** for the qEEG measures was 170. Of the 278 participants who completed a predeployment neurocognitive assessment, 170 of these also completed postdeployment neurocognitive assessment. Data analyses presented in this chapter are based only on data from participants who completed both pre- and post-deployment neurocognitive assessments.

There is, however, considerable variation to the sample sizes available for each analysis. This is a common occurrence in the collection and analysis of multi-channel EEG. Data was excluded as a result of:

- measurement noise due to bad electrodes,
- electrodes that showed biologically implausible values (> 3SDs from the mean), which were set to missing values and therefore excluded from individual analyses; and
- survey data that were missing for particular analyses.

In cases where data were excluded, sample sizes are noted immediately prior to the presentation of each result. It is important to note that the exclusion of a particular electrode site for an individual did not preclude data from other electrodes sites from that participant being included in further analyses.

20.2.4 Data Analysis

A mixed model for repeated measures was used to analyse ERP outcomes (amplitude and latency)) for all 26 electrode sites (Fp1, Fp2, F7, F3, Fz, F4, F8,FC3, FCz, FC4, T3, C3, Cz, C4, T4, P3, CPz, CP4, T5, P3, Pz P4, T6, O1, Oz, O2). This approach allows for repeated measures on the same individuals at two time points (pre- and post-deployment). Study ID was included as a random effect and an unstructured covariance structure was specified to account for variability at each measurement time. The predictor(s) of interest, along with measurement time (pre- and post) and their interaction(s) are included as fixed effects in the model. To control for outliers, all ERP variables were truncated at a three standard deviations cut-off prior to analysis.

For the purpose of this report only results for the working memory updating component (P3wm) are presented. Components relating to target detection were not found to be consistently related to the deployment factors examined for this report. Notably abnormalities in target detection ERPs have been previously found to be

associated with psychopathologies [10], and as such these components require further investigation beyond the scope of the current report.

It is important to note that the results presented in this chapter are preliminary. Given the large number of variables, the results should be considered with some caution as no adjustment was made for multiple testing. Ideally, a more robust analysis is required in order to model both the spatial (26 sites for each subject) and temporal (pre- and post-deployment) nature of the data.

20.3 Results

20.3.1 Number of Prior Deployments

For the purposes of analysing the neurocognitive assessment data, the number of prior deployments was categorised into the following groups:

- No prior deployments
- 1 2 prior deployments
- 3 4 prior deployments
- 5+ prior deployments

20.3.1.1 Centroparietal P3wm amplitude

Significant interactions between time (pre- and post-deployment) and number of prior deployments were observed for the non-target working memory updating P3wm amplitude at central and parietal electrode sites (C3, C4, CP3, CPz and CP4). Results are presented for one representative electrode site, CPz (p=0.022) (Figure 20.3).



Figure 20.3. Depiction of electrode sites with significant interaction effects on a schematic representation of the head for P3wm amplitudes for number of prior deployments.

The means for the effect of prior deployments on changes in P3wm amplitude at site CPz are presented in Table 20.1.

Number of prior deployments	N	Pre-deployment Post-deployment (95% CI) (95% CI)		Change (95% CI)
None	35	9.828	9.144	-0.684
		(8.427, 11.229)	(7.720, 10.568)	(-1.883, 0.514)
1-2 times	56	10.753	10.291	-0.463
		(9.646, 11.861)	(9.165, 11.416)	(-1.410, 0.485)
3-4 times	26	10.402 8.972		-1.431
		(8.777, 12.028)	(7.320, 10.623)	(2.821, -0.040)
5+ times	29	9.355	10.794	1.439
		(7.816, 10.894)	(9.230, 12.358)	(0.122, 2.756)

 Table 20.1: Mean (95% CI) P3wm amplitude at site CPz grouped by number of prior deployments.

The changes observed in P3wm amplitude from pre- to post-deployment indicated that personnel with 5 or more prior deployments increased significantly in P3wm amplitude compared to participants who had no prior deployment (p=0.020), 1 to 2 prior deployments (p=0.022), and participants with 3 to 4 prior deployments (p=0.004). In fact, participants with 4 or fewer deployments, on average, all exhibited a decrease in P3wm amplitude (Figure 20.4).



Figure 20.4: Plot of mean amplitudes (μ V) of the P3wm at site CPz for each group (number of prior deployments) at pre- and post-deployment.

20.3.1.2 Frontocentral and Centroparietal P3wm latency

Significant interactions were identified between time (pre- and post-deployment) and the number of prior deployments for P3wm latency at sites F8, FCz, FC4, C4, CP3, CPz, CP4, T5 (interactions were also observed at occipital sites O1 and Oz, however these findings will be discussed separately). Results are presented for one representative electrode site, FCz (p=0.045) (Figure 20.5).



Figure 20.5: Depiction of electrode sites with significant interaction effects on a schematic representation of the head for P3wm latencies for number of prior deployments.

The means for the effect of prior deployment on changes in P3wm latency at site FCz are presented in Table 20.2.

Number of prior deployments	N	Pre-deployment Post-deployment (95% CI) (95% CI)		Change (95% CI)
None	35	383.390 (376.918, 389.861)	383.431 (375.262, 391.601)	0.042 (-9.598, 9.681)
1-2 times	56	382.659 (377.542, 387.775)	386.294 (379.836, 392.753)	3.636 (-3.985, 11.257)
3-4 times	26	385.726 (378.217, 393.235)	383.696 (374.217, 393.175)	-2.030 (-13.214, 9.154)
5+ times	29	384.138 (377.028, 391.248)	401.793 (392.818, 410.768)	17.655 (7.065, 28.245)

Table 20.2: Mean	(95% CI) P3wm	latency at site F	Cz grouped by n	umber of prior	deployments.
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The changes in P3wm latency between pre- and post-deployment indicated that personnel with 5 or more prior deployments exhibited a statistically significant increase in P3wm latency compared with those with no prior deployments (p=0.016), 1 to 2 prior deployments (p=0.035) and 3 to 4 prior deployments (p=0.013) (Figure 20.6).



Figure 20.6: Plot of mean latencies (ms) of the P3wm at site FCz for each group (number of prior deployments) at pre- and post-deployment.

20.3.1.3 Occipital P3wm latency

Significant interactions were also found between time (pre- and post-deployment) and the number of prior deployments for P3wm latency at occipital electrode sites (O1 and Oz). Results are presented for one representative site at Oz (p=0.023) (Figure 20.7).





The means for the effect of prior deployment on changes in P3wm latency at site Oz are presented in Table 20.3.

Number of prior deployments	N	Pre-deployment Post-deployment (95% CI) (95% CI)		Change (95% Cl)
None	35	377.689	365.235	-12.454
		(369.878, 385.500)	(356.778, 373.692)	(-23.300, -1.608)
1-2 times	56	378.429	370.487	-7.942
		(372.253, 384.604)	(363.801, 377.173)	(-16.516, 0.633)
3-4 times	26	379.829	377.047	-2.782
		(370.766, 388.892)	(367.235, 386.859)	(-15.366, 9.802)
5+ times	29	377.916	389.379	11.464
		(369.334, 386.497)	(380.089, 398.670)	(-0.452, 23.379)

Table 20.3: Mean (95% CI) P3wm latency at site Oz grouped by number of prior deployments.

The changes from pre- to post-deployment in P3wm latency in personnel with no prior deployments (p=0.004), 1 to 2 prior deployments (p=0.010) were significantly smaller compared with the change observed in those with 5 or more prior deployments (Figure 20.8).



Figure 20.8: Plot of mean latencies (ms) of the P3wm at site FCz for each group (number of prior deployments) at pre- and post-deployment.

20.3.2 Prior Combat

20.3.2.1 P3wm amplitude

Significant interactions between time (pre- and post-deployment) and prior combat exposure were observed for P3wm amplitude in left temporal (T3, T5), left centroparietal (CP3), parietal (Pz), and right occipital (O2) electrode sites. Results are presented for one representative site, Pz (p=0.044) (Figure 20.9).



Figure 20.9: Depiction of electrode sites with significant interaction effects on a schematic representation of the head for P3wm amplitude for prior combat exposure.

The means for the effect of prior combat exposure on changes in P3wm amplitude at site Pz are presented in Table 20.4.

Previous combat	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
Νο	107	10.803 (10.034, 11.571)	9.853 (9.107, 10.598)	-0.950 (-1.628, -0.272)
Yes	55	10.209 (9.137, 11.282)	10.454 (9.414, 11.494)	0.244 (-0.702, 1.190)

Table 20.4: Mean (95% CI) P3wm amplitude at site Pz grouped by previous combat expos	sure.
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The change in P3wm amplitude between pre- and post-deployment indicated that personnel with no prior combat exposure exhibited significantly greater decreases in P3wm amplitude, compared to those with prior combat exposure (p=0.044) (Figure 20.10).



Figure 20.10: Plot of mean amplitudes (μ V) of the P3wm at site Pz for each group (prior combat exposure) at pre- and post-deployment

20.3.2.2 Occipital P3wm latency

Significant interactions between time (pre- and post-deployment) and prior combat exposure were observed for P3wm latency at sites occipital sites O1, Oz, and O2. Results are presented for one representative electrode site, Oz (p=0.032) (Figure 20.11).



Figure 20.11: Depiction of electrode sites with significant interaction effects on a schematic representation of the head for P3wm latencies for prior combat exposure.

The means for the effect of prior combat exposure on changes in P3wm latency at site Oz are presented in Table 20.5.

Previous combat	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
No	107	377.728	369.803	-7.925
		(373.351, 382.105)	(364.660, 374.946)	(-14.107, -1.744)
Yes	55	377.406	381.106	3.700
		(371.301, 383.512)	(373.933, 388.279)	(-4.922, 12.322)

Table 20.5: Mean (95	5% CI) P3wm latency	at site Oz grouped b	y previous combat exposure.
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The change in P3wm latency between pre- and post-deployment indicated that personnel with no prior combat exposure exhibited greatest reduction in P3wm latency, compared to those with prior combat exposure (p=0.032) (Figure 20.12).



Figure 20.12: Plot of mean latencies (ms) of the P3wm at site Oz for each group (prior combat exposure) at pre- and post-deployment.

20.3.3 Length of Recent Deployment

The length of time (months) spent on the most recent deployment was categorised into the following three groups:

- ≤ 5 months
- 6 or 7 months
- 8 12 months

20.3.3.1 Frontocentral, central and centroparietal P3wm amplitude

Significant interactions between time (pre- and post-deployment) and the length of recent deployment were observed for P3wm amplitude at sites F7, F8, FC3, FCz, FC4, T3, C3, Cz, C4, CP3, and CPz. Results are presented for one representative electrode site, Cz (p=0.010) (Figure 20.13).



Figure 20.13: Depiction of electrode sites with significant interaction effects on a schematic representation of the head for frontocentral and centroparietal P3wm amplitudes for length of recent deployment.

The means for the effect of the length of most recent deployment on changes in P3wm amplitude at site Cz are presented in Table 20.6.

Length of recent deployment (months)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% Cl)
≤ 5moths	63	10.094	10.481	0.387
		(8.923 <i>,</i> 11.266)	(9.299 <i>,</i> 11.664)	(-0.592 <i>,</i> 1.366)
6 or 7 months	38	8.615	9.605	0.989
		(7.106, 10.124)	(8.082, 11.127)	(-0.271, 2.250)
8 - 12 months	69	9.216	7.994	-1.222
		(8.096, 10.336)	(6.864, 9.124)	(-2.158, -0.287)

 Table 20.6: Mean (95% CI) P3wm amplitude at site Cz grouped by length of recent deployments.

The change in P3wm amplitude from pre- to post-deployment between groups indicated that personnel deployed for 8 to 12 months exhibited a significantly greater decrease relative to personnel deployed for ≤ 5 months (p=0.020) or 6 to 7 months (p=0.006) (Figure 20.14).



Figure 20.14: Plot of mean amplitudes (μ V) of the P3wm at site Cz for each group (length of recent deployment) at pre- and post-deployment.

20.3.3.2 Occipital P3wm latency

Significant interactions between time (pre- and post-deployment) and length of current deployment were observed for P3wm latency at occipital sites O1, Oz. Results are presented for one representative site, Oz (p=0.025) (Figure 20.15).



Figure 20.15: Depiction of electrode sites with significant interaction effects on a schematic representation of the head for occipital P3wm latencies for length of recent deployment.

The means for the effect of current deployment length on P3wm latency are presented in Table 20.7.

Length of recent deployment (months)	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
≤ 5moths	63	378.716	379.670	0.954
		(373.012, 384.420)	(373.036, 386.305)	(-7.052, 8.960)
6 or 7 months	38	370.737	372.927	2.190
		(363.392, 378.082)	(364.384, 381.469)	(-8.118, 12.499)
8 - 12 months	69	380.799	368.453	-12.346
		(375.348, 386.249)	(362.114, 374.793)	(-19.996, -4.695)

Table 20.7: Mean (95% CI) P3wm latency at site Oz grouped by length of recent deployment.

At pre-deployment, personnel deployed for 6 to 7 months exhibited significantly shorter P3wm latencies than personnel deployed for 8 to 12 months (p=0.031). The change in P3wm latency between pre- and post-deployment, indicated that personnel deployed for 8 to 12 months exhibited the greatest decrease relative to personnel deployed for ≤ 5 months (p=0.013) or 6 to 7 months (p=0.027) (Figure 20.16).



Figure 20.16: Plot of mean latencies (ms) of the P3wm at site Oz for each group (length of recent deployment) at pre- and post-deployment.

20.3.4 Traumatic Deployment Experiences

The number of traumatic deployment experiences was categorised into the following groups:

- 0 16 Low/Medium exposures
- 17 35 High exposures
- 36+ Very High exposure

Significant interactions between time (pre- and post-deployment) and traumatic deployment exposures were observed for P3wm amplitude at sites Pz and O1. Results are presented for one representative site, Pz (p=0.024) (Figure 20.17).



Figure 20.17: Depiction of electrode sites with significant interaction effects on a schematic representation of the head for P3wm amplitude for traumatic deployment exposures.

The means for the effect of deployment exposures on changes in P3wm are presented in Table 20.8.

Deployment Exposures	N	Pre-deployment (95% Cl)	Post-deployment (95% Cl)	Change (95% CI)
0 - 16 Exposures	28	10.494	9.494	-1.000
		(9.002, 11.986)	(8.010, 10.977)	(-2.313, 0.312)
17 - 35 Exposures	46	11.664	10.150	-1.514
		(10.500, 12.828)	(8.993, 11.308)	(-2.538, -0.490)
36+ Exposures	72	9.794	10.040	0.247
		(8.863, 10.724)	(9.115 <i>,</i> 10.966)	(-0.572, 1.066)

Table 20.8: Mean	(95% CI) P3wm	amplitude at s	site Pz grouped	by deployment	exposures.
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At pre-deployment personnel in the very high (36 or more) exposure range exhibited significantly reduced P3wm amplitudes than personnel in the high (17 to 35) exposure range (p=0.014). The change in P3wm amplitudes between pre- and post-deployment indicated that personnel in the 17-35 exposure range exhibited a greater reduction relative to those in the 36+ exposure range (p=0.009) at site Pz (Figure 20.18).



Figure 20.18: Plot of mean amplitudes (μ V) of the P3wm at site Pz for each group (traumatic deployment exposures) at pre- and post-deployment.

At site O1 personnel who met the criteria for the 0-16 exposure group exhibited the greatest amplitude reduction relative to 17-35 exposures (p=0.018) and 36+ exposures (p=0.004). Taken together, these results are indicative of a pattern of reduced P3wm amplitude between pre- to post-deployment for those in the 0-16 and 17-35 exposure group, in contrast to an already reduced but stable pattern exhibited by those in the very high exposure range.

20.4 Summary of Results

Table 20.9 summarises the key findings presented in this results section. The following section will then discuss these with reference to literature which has already been published.

Question	Significant Associations
Q1. Association between the number of prior deployments and changes in P3wm.	Participants with 5 or more prior deployments increased significantly in the centroparietal P3wm amplitude in a number of regions between pre- and post-deployment, compared participants who had 4 or fewer deployments, who all exhibited a decrease between pre- and post-deployment.
	Participants with 5 or more prior deployments exhibited a significantly greater increase in P3wm latency in the frontocentral and centroparietal regions between pre- and post-deployment, than participants who had 4 or fewer deployments.

Table 20.9: Summary of key finding	s presented in this chapter
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	Participants with 5 or more prior deployments exhibited significantly greater increase P3wm latency in the occipital region between pre- and post-deployment, than participants who had 4 or fewer deployments.
Q2. Association between previous combat experience and changes in P3wm.	Participants with no prior combat exposure exhibited significantly greater decreases in P3wm amplitude in a number of regions between pre- and post-deployment compared to those with prior combat exposure.
	Participants with no prior combat exposure exhibited a significantly greater reduction in P3wm latency in the Occipital region between pre- and post-deployment, compared to those with prior combat exposure.
Q3. Associations between length of most recent deployment and changes in P3wm.	Participants who deployed for 8 to 12 months exhibited significantly greater decreases in P3wm amplitude in a number of regions between pre- and post-deployment, compared to those who had deployed for seven or fewer months.
	Participants who deployed for 8 to 12 months also exhibited significantly greater decreases P3wm latency at a number of regions between pre- and post-deployment, compared to those who had deployed for seven or fewer months.
Q4. Associations between traumatic deployment experiences and changes in P3wm.	Participants with 17 to 35 traumatic deployment exposures exhibited a significantly greater reduction in P3wm parietal region between pre- and post-deployment, in comparison to those who reported 36 or more traumatic deployment exposures.
U	Participants with 0 to 16 traumatic deployment exposures exhibited a significantly greater reduction in P3wm in the occipital region between pre- and post-deployment, in comparison to those who report 17 or more traumatic deployment exposures.

20.5 Discussion

A number of significant changes in **working memory updating, measured by changes to the ERP P3wm** component between pre- and post-deployment were identified in these analyses. While findings presented in this chapter relate to preliminary analyses of the data and therefore, should be interpreted with caution, significant changes were found to be associated with both prior and most recent deployment experiences.

20.5.1 Number of Prior Deployments

20.5.1.1 P3wm Amplitude

A complex pattern of results associated with the number of prior deployments, was found for working memory updating in the central and centroparietal regions. These results indicated that personnel with two or fewer prior deployments exhibited relatively stable levels of working memory updating between pre- and post-deployment. Participants with three to four prior deployments, however, exhibited a *significant reduction* in P3wm amplitude suggesting increased impairment to updating working memory. In comparison, participants with five or more prior deployments exhibited a *significant increase* in P3wm suggesting an increase in the effort used to update working memory, between pre- and post-deployment.
The finding that those with three to four prior deployments had a significant reduction in the effort used for updating working memory between pre- and post-deployment is consistent with other studies that have demonstrated reduced P3wm amplitudes in, for example, individuals diagnosed with PTSD [15, 16]. For example, a study involving 18 participants with PTSD and 18 controls revealed significant widespread right hemisphere amplitude attenuation in ERP activity during working memory updating in PTSD [17], an area critical to the updating and storage in working memory [18].

In comparison, the pattern of increased P3wm amplitude for participants with five or more prior deployments, suggests an increase in the effort required to update working memory. However, Blomhoff et al [19] has also suggested that increased P3 amplitude may also be associated avoidance or arousal symptoms in individuals diagnosed with PTSD.

It is also possible that this bi-directional finding may be indicative of unit-related effects, as those with the greatest number of prior deployments may also belong to specific units (i.e. long term career soldiers versus units with higher personnel turnovers). Nevertheless, this bi-directional effect remains difficult to interpret and therefore is an area that requires further investigation.

20.5.1.2 Frontocentral P3wm Latency

A significantly longer latency was observed during working memory updating for those participants with five or more prior deployments. This observed delay within fronto-central and centro-parietal regions related to the number of prior deployments is indicative of slowed information processing which has previously been observed in individuals with PTSD over similar frontal sites [15]. In contrast, participants with less than five previous deployments exhibited relatively stable P3wm latencies between pre- and post-deployment which suggested the time taken to update working memory did not change for these participants.

This finding indicates that experiencing a higher number of deployments may be associated with a vulnerability to a slowing of working memory updating processes. As this effect was not present at pre-deployment in any of the groups with prior deployments, it is unclear whether this delay remains pervasive or normalises with time. This finding requires further longitudinal investigation.

20.5.1.3 Occipital P3wm latency

The number of prior deployments was also found to be associated with changes to the P3wm latency at the occipital sites. Those participants with two or fewer prior deployments, on average, showed significantly reduced latencies between pre- and post-deployment.

The observed reductions in P3wm latency may indicate that deployment is associated with faster visual processing in groups with two or fewer prior deployments. A prospective study conducted by Vasterling et al [20] also found that deployment was associated with reduced reaction times between pre- and post-deployment. The authors in this study suggested that increased reaction times may be a result of increased in arousal developed on deployment as a response to potentially threatening environments. However, the findings in this study require further investigation in order to further examine the longitudinal trajectories of change in these systems.

20.5.2 Prior Combat

20.5.2.1 P3wm Amplitude

Prior combat exposure was associated with a significant reduction, on average, in P3wm amplitude from pre- to post-deployment in participants with no prior combat exposure which suggests increased impairment to updating working memory processes. In comparison, those with prior combat exposure exhibited relatively stable P3wm amplitude between pre- and post-deployment.

The observed reduction in P3wm amplitude for those with no prior combat experience suggests that even one battlefield experience may impair an individual's working memory function following deployment. This is in contrast to individuals who reported previous combat experience, who showed no change from pre- to post-deployment. As there was no difference between combat and no combat at pre-deployment the suggestion is that these changes are transient. However, this requires further longitudinal investigation of outcome trajectories.

20.5.2.2 P3wm Latency

Prior combat exposure was associated with reduced P3wm latency in the occipital region. Those with no prior combat exposure exhibited significantly shortened P3wm latencies between pre- and post-deployment, whereas those with prior combat exposure exhibited relatively stable latencies across time.

The observed reduction in occipital P3wm latencies associated with working memory updating may indicate that combat exposure is associated with faster visual processing at post-deployment in personnel with no prior exposure at predeployment. This may reflect a conditioned response to prolonged exposure in an environment that requires fast visual processing (i.e. threat of engagement with enemy).

Nevertheless, results should be interpreted tentatively as the occipital cortex is not generally associated with a strong P3wm effect [21]. It is also not clear whether the observed changes are due to combat exposure on the current deployment, or to more general deployment related-factors. The lack of difference between those with prior combat exposure and those with no combat exposure at pre-deployment suggests that these changes are transient. However, they may suggest a propensity for participants who have previously been exposed to combat to be at risk of further disruptions to working memory function, which is compatible with the concepts of sensitization and kindling [22]. Further investigation would be required in order to examine this hypothesis and also the longitudinal trajectories of change in these systems.

20.5.3 Length of Most Recent Deployment

Participants who deployed for eight to twelve months on the most recent deployment, were found to have both a significant reduction in the P3wm amplitude (central, frontocentral and centropartietal regions) from pre- to post-deployment. In comparison, those with shorter deployment lengths (≤5 months and 6 to 7 months) tended to exhibit relative stable levels of P3wm amplitude between pre- and post-deployment.

Again, the observed reduction in P3wm amplitude for those with the longest deployment lengths suggest that prolonged exposure to deployment environments could compromise working memory updating systems. In contrast, those with shorter deployment lengths showed comparatively little change from pre- to post-deployment. Further longitudinal investigation is required to examine whether the observed decrements for P3wm amplitude normalise or remain persistent over extended periods of time.

Notably significant pre-deployment differences were also observed for P3wm latency. Participants who experienced the longest deployments lengths (8 to 12 months) exhibited the most prolonged latencies at pre-deployment. Whilst the cause of this pre-deployment difference remains unclear, this group also exhibited the shortest and most significant reduction in P3wm latency at post-deployment.

Shorter P3wm latency may indicate that exposure to deployment is associated with faster processing of visual information in groups with the longest deployment lengths (8 to 12 months). This finding shows some consistency with previous research which has reported enhanced reaction times following military deployment [20]. As suggested earlier, shortened P3wm latency in the occipital region may be a response to prolonged exposures to an environment that requires fast visual processing. This effect would be further exacerbated for participants who were on deployment for longer periods of time. These findings require further investigation to examine the longitudinal trajectories of change in these systems.

20.5.4 Deployment exposures

Deployment exposures were found to be associated with a significant reduction in P3wm amplitude in parietal regions. A pattern of reduced P3wm amplitudes for personnel with 0-16 and 17-35 deployment exposures between pre- and post-deployment, suggests increasing impairment during the updating of information in working memory. The reduced but stable trajectory of P3wm amplitudes between pre- and post-deployment for personnel with 36 or more exposures may suggest a pervasive, but relatively constant impairment to the working memory updating systems.

Although reduced P3wm amplitude at pre-deployment requires further investigation which is beyond the scope of this study, initial disparities between groups may have been influenced a possible unit membership effect. For example, personnel or units with the highest levels of exposure on the most recent deployment may also have previously experienced high levels of exposure on prior deployments which in turn, may have already adversely impacted their working memory function.

20.6 Summary

While these preliminary results should be treated with some caution, the overall pattern of findings suggests that both previous and current deployment experiences may have effected and may continue to effect working memory updating processes. Furthermore, there is again some evidence to suggest that these impacts may have flow-on effects in relation to subsequent deployments (a sensitising effect). Similar changes to working memory updating observed in this study have also been identified in individuals diagnosed with psychological disorders. However, whilst it is clear that changes in working memory processing occur over the course of deployments, the longitudinal trajectories and possible long term impact of such changes on individual function remain uncertain.

Next, Chapter Twenty One which focuses on **allostatic load**, concludes this section of the report. Once again, after providing a short introduction, an explanation of the measure is provided before presenting the primary results. The chapter again concludes with a discussion of these results in relation to the current literature.

Finally, Chapter Twenty Two summarises the **Conclusions and Limitations** of the report.

20.7 Further Analyses

The findings presented in this chapter are only preliminary. A more robust analysis is therefore, required in order to model both the spatial (26 sites for each subject) and temporal (pre- and post-deployment) nature of the data. While this unique dataset provides the opportunity to address numerous issues pertinent to the health of deploying populations, there are a number of specific questions which could initially be considered:

- Is lifetime trauma exposure associated with changes in working memory from pre- to post-deployment?
- Is trauma exposure on current deployment associated with changes in working memory from pre- to post-deployment?
- Is there an association between changes in psychological distress (as measured by the K10) from pre- to post-deployment and changes in working memory from pre- to post-deployment?
- Is there an association between change in PCL scores from pre- to postdeployment and changes in working memory from pre- to post-deployment?
- Is there an association between lifetime mTBI reported at pre-deployment and working memory at pre-deployment?
- Is a new mTBI reported at post-deployment associated with changes in working memory from pre- to post-deployment?

In addition, a number of other paradigms were also assessed by the MEAO Prospective Study in order to understand changes to neurocognitive functioning between pre- and post-deployment. These paradigms which include response inhibition, startle and emotional processing, require extensive analyses.

20.8 References

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Chapter Twenty One – Allostatic Load

Key Points

- 1. **Small but significant increases in mean allostatic load scores** were identified between pre- and post-deployment.
- 2. Cumulative scores based on prescribed measures may not be the most appropriate method for identifying the specific markers of risk for future morbidity or mortality.
- 3. An alternative method based on **latent class analysis may prove to be a more effective** way of estimating allostatic load for military populations.

This chapter presents and discusses the findings relating to allostatic load which combines a number of objective measures in order to calculate the potential future risk of morbidity or mortality. The chapter begins by briefly discussing the current literature pertaining to allostasis and allostatic load. Primary results are then provided, beginning with a comparison between the allostatic load scores reported at pre-deployment by responders who only completed a pre-deployment physical test, and those responders who completed both a pre- and post-deployment physical test. All subsequent analyses within the results section include only those participants who have completed both the pre- and post-deployment measures which in combination form the allostatic load score. The chapter concludes by discussing the primary findings pertaining to allostatic load. Other chapters which also discuss findings pertaining to this chapter include Chapter Twelve (Cardiovascular Health), Chapter Thirteen (Respiratory Health) and Chapter Fifteen (Biochemistry).

21.1 Introduction

The emergence of multiple health complaints and non-specific symptoms in the aftermath of military deployments is a source of considerable debate. There is increasing evidence that the stress of deployment dysregulates a series of homeostatic systems that underpin the risk for a number of diseases. These systems include the nervous system which regulates the body's neuroendocrine responses to stress; the immune system which is responsible for fighting infections throughout the body; the metabolic system which facilitates food intake and the production of energy for the body through adrenal steroids; and the cardiovascular system. The pattern of dysregulation of these systems is called allostatic load.

Allostasis recognises that physiological states change over time, and that both physical and psychological stressors elicit various physiological reactions in an attempt to return to what is the steady state at that particular time (1). Repeated action by physiological systems in an effort to deal with physical and/or psychological stressors (1) produces continuous wear and tear across multiple physiological systems, contributing to a person's health risk (2).

The allostatic load model has been used to refocus the stress disease literature, emphasising that their multiple biological systems are vulnerable to a temporal cascade of dysregulation (3). Progressive dysregulation leads to the emergence of a range of disease trajectories that arise from this common pathway. This approach provides a broader construct than traditional detection methods used in biomedical practice for understanding how repeated challenges from the environment lead to increasingly maladaptive disruptions of physiological systems.

Stressors which may be of significant relevance to a military population include work stress, particularly where personnel are dealing with a combination of psychological and physical stress, as may occur in combat situations (4). Studies have found allostatic load to be associated with a number of different health outcomes, including a significantly greater risk for mortality and marginally higher likelihood of suffering from cardiovascular disease (5), psychological disorders such as PTSD (6) and depression (7). Lastly, decreases in cognitive function have also been associated with an increased allostatic load (8, 9).

It is also the case that the concepts of allostasis and allostatic load can be applied to the identification of resilience factors which protect individuals against physical and psychological stressors (10). For example, high levels of social support and social integration have been found to be associated with significantly lower allostatic load scores (11).

21.2 Measures

The following objective measures (and risk cut-offs) collected as part of both the preand post-deployment physical testing component of this study (see Appendix D).were used to calculate and then identify changes in allostatic load between pre- and postdeployment. Where available, designated reference ranges were applied, however, for the continuous measures, high risk was defined using values greater than the 3rd quartile at pre-deployment.

Inflammation and immune systems

- Interleukin 6 (If > 0)
- C-reactive protein (> 0.9)
- Tumour-necrosis factor alpha (if > 0)

Metabolic systems

- HbA1c (if > 5.6)
- High density lipoprotein cholesterol (if > 1.5)
- Low density lipoprotein cholesterol (if > 3)
- Triglycerides (if > 1.8)
- Total cholesterol (if > 5)

Cardiovascular and respiratory systems

- Resting pulse rate (if > 75)
- Systolic and Diastolic blood pressure (at least mild hypertension)

Anthropometric Indicators

• Waist to hip ratio (classed as having abdominal obesity)

In order to calculate the allostatic load score, one point was given each time an individual fell above the designated cut-off. As 12 indicators were used, the maximum score denoting the highest risk of future morbidity or morality was 12 and the minimum score was 0.

21.2.1 Questions to be Addressed

The following questions, which were informed by the literature review, are examined in this chapter:

- 1. Is there an association between **length of most recent deployment** and changes in allostatic load, between pre- and post-deployment?
- 2. Is there an association between **roles on most recent deployment** and changes in allostatic load, between pre- and post-deployment?
- 3. Is there an association between **traumatic deployment experiences** while on most recent deployment, and a change in allostatic load, between pre- and post-deployment?
- 4. Is there an association between **total length of time spent on deployment** in the previous three years and a changes in allostatic load, between pre- and post-deployment?
- 5. Is there an association between the **number of previous deployments** and a changes in allostatic load, between pre- and post-deployment?
- 6. Is previous **combat experience** associated with changes in allostatic load between pre- and post-deployment?
- 7. Is there an association between **changes in psychological distress** and changes in allostatic load, between pre- and post-deployment?
- 8. Is there an association between **change in PTSD symptoms** and changes in allostatic load, between pre- and post-deployment?
- 9. Is there an association between **somatic symptom scores** and changes in allostatic load, between pre- and post-deployment?
- 10. Is there an association between the **psychological co-morbid groups** and changes in allostatic load, between pre- and post-deployment?

21.2.2 Sample Sizes

The total sample size used **to identify change between pre- and post-deployment** allostatic load is 324. Of the 399 participants who completed both a pre- and a post-deployment physical testing, 75 were not available for at least one of the measures at pre- or post-deployment and therefore excluded from the analyses.

The total sample size used **to compare the mean pre-deployment** allostatic load for pre-deployment only participants, with pre- and post-deployment participants, was 224. Of the 256 participants who completed a pre-deployment physical test only, 32 were not available for at least one of the measures at pre-deployment and therefore excluded from the analyses.

21.2.3 Data Analysis

A cumulative measure of allostatic load was calculated similar to that used in the MacArthur Successful Aging Study. This cumulative method classifies each of the measures into quartiles based on their distribution. Participant scores will then be dichotomized according to whether (1) or not (0) their score falls into the highest risk quartile for that measure. The scores for all included measures will then be summed in order to identify the individual's cumulative allostatic load score (4). A total

allostatic load score was calculated for pre- and post-deployment, then changes in scores between pre- and post-deployment were categorised (increase, decrease, no change).

The change categories were then used as a three level categorical outcome in a multinominal logit model. This approach allowed for the shift in allostatic load between the two time points to be examined. In all models the default reference category was 'no change'. Where a different reference category was used, this is stated in the text.

21.3 Results

A comparison of the mean number allostatic load score for respondents who only completed the pre-deployment with those that completed all of the allostatic load measurements at both pre- and post-deployment was undertaken Table 21.1 (Appendix Z). The mean allostatic load score at pre-deployment was not significantly different (p= 0.141) for respondents who only completed a pre-deployment survey compared to those who completed both a pre- and post-deployment survey.

As presented in Table 22.1, for respondents who completed all of the allostatic load measures at both pre- and post-deployment, the mean scores were 2.25 and 2.50 respectively (change = 0.25, 95% Cl 0.06, 0.44), and this change was significant (p=0.01) (Table 21.3, Appendix Z).

 Table 21.2 Summary of mean allostatic load and change scores for respondents completing both

 pre- and post-allostatic load

Pre-Post-Deployment N	Pre- Deployment Mean	Post-Deployment Mean	Change mean (CI)
324	2.25	2.50	0.25 (0.06, 0.44)

21.3.1 Length of Most Recent Deployment

The proportion of participants with increases, decreases or no change in allostatic load score, for length of most recent deployment are presented in Table 21.4. As can be seen from this table there was a significant association between length of most recent deployment and the change allostatic load score between pre- and post-deployment.

 Table 21.4: Percentage of respondents in each Allostatic load category, for each category of most recent deployment length

Length of most	Ν	Allostatic load	Allostatic load	Allostatic load
recent deployment		Increase	Decrease	No change
(months)				
≤ 5months	77	44.2%	24.7%	31.2%
6 or 7 months	121	42.3%	39.7%	18.2%
8 months	87	37.9%	40.2%	21.8%
9-12 months	39	56.4%	15.4%	28.2%

Using '<=5 Months' as the predictor reference, and 'No change' as the outcome reference, there was a significant association between the length of most recent deployment and allostatic load change categories. As can be seen in Table 21.4, compared to those away for less than or equal to 5 months, a greater proportion of

participants away for 6-7 months (p=0.01, OR=2.76, 95% CI 1.26, 6.05) and 8 months (p=0.04, OR=2.33, 95% CI 1.02, 5.29) had a decrease in allostatic load scores, compared to no change. However, for those deployed between 9-12 months a lower proportion had decreased in allostatic load score, but this difference was not statistically significant (p=0.53, OR=0.69, 95% CI 0.22, 2.20).

The significant association between length of most recent deployment is illustrated in Figure 21.1, which shows the probability of allostatic load scores increasing, decreasing or not changing for each category of length of most recent deployment.





21.3.2 Role on Most Recent Deployment

Table 21.5 (Appendix Z) shows the percentage of participants in each allostatic load change category for the role on most recent deployment. Using 'Outside Afghan' as the predictor reference, and 'No change' as the outcome reference, there was no significant association between role on most recent deployment and allostatic load category change.

21.3.3 Traumatic Deployment Experiences Total Score

The proportion of participants with increases, decreases or no change in allostatic load scores for each category of deployment exposure scores are presented in Table 21.6 (Appendix Z). Using 'Low exposures' as the predictor reference, and no change as the outcome reference, there was no significant association between deployment exposure category and allostatic load category change.

21.3.4 Traumatic Deployment Experience Categories

The proportion of respondents in each allostatic load change category, who had indicated Yes or No to at least one exposure to each of the nine categories of deployment experiences is summarised in Table 21.7 (Appendix Z). Note that each respondent could have responded positively to more than one item. Using 'No exposure' as the predictor reference, and 'No change' as the outcome reference, there were no significant associations between any of the deployment exposures and change in allostatic load between pre- and post-deployment.

21.3.5 Number of Prior Deployments

The proportion of participants with increases, decreases or no change in allostatic load score, for number of prior deployments are presented in Table 21.8 (Appendix Z). As can be seen from this table, there was no significant association between number of prior deployments and the change in allostatic load score between preand post-deployment.

21.3.6 Total Time on Prior Deployments

The proportion of participants with increases, decreases or no change in allostatic load score, for total time on prior deployments are presented in Table 21.9 (Appendix Z). As can be seen from this table there was no significant association between total time on prior deployments and the change allostatic load score between pre- and post-deployment.

21.3.7 Previous Combat Experiences

An analysis of the percentage of participants in each allostatic load change category (Increase, Decrease, No change) for participants who had, and had not reported previous combat exposure, was also conducted (Table 21.10, Appendix Z). There was no significant association between previous combat exposure and allostatic load change.

21.3.8 K10 change

The proportion of participants with increases, decreases or no change in allostatic load scores for each category of K10 change (increase, decrease, No change) are presented in Table 21.11 (Appendix Z). Using no change as the predictor reference, and no change as the outcome reference, there was no significant association between K10 change and allostatic load change.

21.3.9 PCL-C change

The proportion of participants with increases, decreases or no change in allostatic load scores for each category of PCL-C change (increase, decrease, No change) are presented in Table 21.12 (Appendix Z). Using no change as the predictor reference, and no change as the outcome reference, there was no significant association between PCL-C change and allostatic load change.

21.3.10 Somatic symptoms

The mean number of somatic symptoms at post-deployment for each category of allostatic load change (Increase, Decrease, No change) are presented in Table 22.13 (Appendix Z). There was no significant association between number of symptoms at post-deployment and allostatic load change.

21.3.11 Psychological Co-morbidity

The proportion of participants with increases, decreases or no change in allostatic load scores for each number of psychological conditions at post-deployment are presented in Table 21.14 (Appendix Z). Using no psychological conditions as the predictor reference and no change as the outcome reference, there was no significant association between number of psychological conditions at post-deployment and changes in the mean allostatic load scores.

21.4 Summary of Results

Table 21.15 summarises the key findings presented in this results section in relation to the questions posed in Section 21.2.1 of this chapter. A discussion section which draws together these findings with reference to literature which has already been published is then provided.

Question	Significant Associations
Q1. Total length of prior deployments in last 3 years.	Nil
Q2. Number of previous deployments.	Nil
Q3. Length of most recent deployment.	Participants who were away for 6 to 7 months and 8 months had a decrease in allostatic load, compared to those away for less than or equal to 5 months.
Q4. Roles on most recent deployment.	Nil
Q5. Traumatic deployment experiences.	Nil
Q6. Combat experience.	Nil
Q7. Changes in psychological distress	Nil
Q8. Changes in PTSD symptoms	Nil
Q9. Changes in somatic symptoms.	Nil
Q10. Changes in psychological co-morbidity.	Nil

 Table 21.15: Summary of key findings presented in this chapter

21.5 Discussion

The overall mean allostatic load score for participants that completed both the preand post-deployment measures was significantly higher at post-deployment in comparison to pre-deployment. However, this shift was small and apart from length of most recent deployment there were no significant associations between changes in allostatic load and deployment related experiences and exposures. The fact that some deploying personnel even in high stress environments had a decrease in allostatic load was unexpected. These results show different patterns of adaptation to high stress environments and the reason for this requires further exploration. The role of prior training and unit membership are potential explanations which require consideration. It should also be noted that the collection of cortisol, adrenaline and noradrenaline was ceased and therefore, could not be included in the cumulative score of allostatic load in this study. Previous studies (6, 11-16) have shown these to be important indicators.

Another reason for this lack of significant findings may relate to the way in which allostatic load was calculated in this study. Similar to the MacArthur Successful Aging Study, which was one of the first programs of research to test the model of allostatic load, the MEAO Prospective Study used a cumulative model which classified each of their measures into quartiles based on their distribution. One point was given for each time an individual fell into the highest risk quartile. These scores were summed in order to identify the individual's cumulative allostatic load score (4). In the case of the MacArthur Successful Aging Study ten measures were used and therefore the highest allostatic load score was ten and the lowest was zero. Many subsequent studies have also followed a similar scoring system (6, 14, 17, 18).

Nevertheless, several limitations in this cumulative scoring system have been identified (16). First, the assignment of high risk quartiles is arbitrary and may not reflect an appropriate cut-off. Nor should it be assumed that the same cut-off should be used for each population. Second, there is no opportunity to weight the measures according to their ability to predict particular outcomes such as cardiovascular health.

In realising the limitations of the cumulative score model, Seeman et al. (19) investigated alternative models of calculating an allostatic load score. A meta-factor allostatic load model was devised with core domains of inflammation and metabolism. This provided a much better fit than the cumulative scoring model, representing 84% of the pattern of association. Several studies have also used z-scores with mixed results. This method is based on averaging the normal scores (z scores) for each of the parameters. Seeman (8) compared this method to the traditional cumulative scoring system, and found that both yielded essentially the same result, although the latter showed a stronger effect. Hawkley et al (20) successfully used z-scores to show a significant association between socio-economic status and allostatic load. Mair (21) also used z-score, however in this case the results did not differ significantly from the traditional cumulative scoring system.

Using a principal component factor analysis, Buckwalter et al (22) identified a seven factor model – stress hormones, metabolic syndrome, pre-inflammatory elements, cholesterol, blood sugars, blood pressure and combination а of dehydroepiandrosterone, peak flow and insulin-like growth factors. This model was also found to predict more of the variance in tertiary outcomes such as depression and anxiety, in comparison to the cumulative allostatic load score. Further work to identify the most appropriate way of calculating the allostatic load index is therefore warranted.

In addition to those methods mentioned above, latent cluster analysis, used to identify underlying clusters of individuals who share common factors, may also be helpful in identifying measures of allostatic load. The benefit of using this method in comparison to factor analysis or the more arbitrary cumulative method is that it can identify clusters of individuals who share common dysregulation. While a latent class analysis may have proved more informative in looking at allostatic load in this particular population, it was well beyond the scope of this initial report.

21.5.1 Length of Most Recent Deployment

As noted above, length of most recent deployment was the only variable to be significantly associated with changes to allostatic load scores between pre- and post-deployment. Surprisingly the analyses showed that allostatic load was more likely to decrease for those respondents who were away six to seven or eight months compared to those respondents who were only away for five months on the most recent deployment.

One possible reason for this finding is that moving into and out of deployment zones may place a toll on the human body, above and beyond that picked up by other indicators such as the psychological distress (Chapter Five), PTSD symptoms (Chapter Seven), alcohol use (Chapter Eight) or number of somatic symptoms (Chapter Ten). The precise nature of the work being undertaken by those participants who were deployed for between six and eight months needs to be determined, as this finding may reflect that the roles for individuals with shorter durations may be more challenging and this accounted the association between length of deployment and changes to allostatic load. Two types of stressors can lead to an increase in allostatic load. The first is physical exertion, such as dealing with radical changes in the immediate environment including temperature or responding to an infection. Second, psychological stressors including fear and anxiety, may challenge the physiological systems (4). Most daily life challenges, whether physical and/or psychological, temporarily activate a physiological response without any long term side effects. Inappropriate responses to daily challenges, however, may increase allostatic load. Three types of inappropriate responses have been identified - those resulting from frequent acute challenges, a failure to either adapt to or shut off after the challenge has abated, or physiological systems not responding appropriately (12, 23).

The finding that shorter lengths of deployment but not role type or prior combat trauma, for example, may support the previous findings that it is a combination of environmental, physical and psychological stress that impacts on allostatic load. However, it is important to note that these findings should also be treated with caution in that the measures which have been pre-defined as measurements of allostatic load may not be providing an accurate picture of the true risk for future morbidity or mortality. Equally other relevant measures in this sample were collected by not analysed because of the absence of change or missing data. Hence these findings should be seen as preliminary.

21.6 Summary

While the overall mean allostatic load significantly increased between pre- and postdeployment, the shift was small and apart from length of most recent deployment was not associated with any other deployment related factors. However, this was a particularly healthy population and therefore it would be unlikely, given that these measures were collected after deployment it is perhaps not surprising that no other significant associations were identified.

It may also be the case, that the cumulative method for calculating allostatic load was not appropriate for this population. Previous literature has already raised this issue suggesting that more appropriate methods. One of the most promising methods that potentially could be used to identify the specific markers which most predict changes to risk of future mortality and/or morbidity, is latent class analysis.

The final section in this report presents a summary of findings and the conclusion.

21.7 Other Chapters of Relevance

- Chapter Twelve Cardiovascular Health
- Chapter Thirteen Respiratory Health
- Chapter Fifteen Biochemistry

21.8 Further Analysis

In order to overcome the inadequacies of using a cumulative score to measure allostatic load in a healthy population, latent class analysis which identifies the specific markers most likely to predict the risk of future mortality and/or morbidity is required.

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Chapter Twenty Two – Conclusions

Key Points

- 1. Both combat exposure and operating outside of the main support base were found to be associated with post-deployment psychological dys-regulation in particular, for individuals who had little or no evidence of significant dys-regulation prior to deployment.
- 2. **Prior trauma exposure and other traumatic life experiences** were significantly associated with co-morbid psychological conditions at post-deployment, particularly in the case of those participants who were found to have three psychological conditions at post-deployment assessment.
- 3. The number and time away on previous deployments were significantly associated with shifts in neurocognitive functioning, with findings suggesting that deployments have left ongoing evidence of increased arousal and decreased efficiency.

This final chapter summarises the findings from the MEAO Prospective Study which have been presented and discussed throughout the previous chapters. The chapter begins by summarising the primary aims of the study before looking at the overall physical, mental and social health and wellbeing of these participants.

The general hypotheses investigated by the MEAO Prospective Study were:

- 1. combat exposure, which entails a complex set of adaptations and exposures, will predict the greatest post-deployment dys-regulation in individuals who had little or no evidence of significant dys-regulation prior to deployment,
- 2. individuals with the greatest degree of pre-deployment dys-regulation will be most vulnerable to combat stresses on deployment, with both adverse physical and psychological health consequences; and
- 3. prior to deployment there will be significant differences in dys-regulation determined by previous deployments, trauma exposure and other lifetime experiences.

Although beyond the scope of this particular report, the study was also designed to test the following hypotheses:

- 4. the range of non-specific symptoms typically associated with postdeployment syndromes (somatic symptoms) will predict the degree to which underlying biological systems are dys-regulated; and
- 5. the range of psychological symptoms will also predict the degree to which underlying biological systems are dys-regulated.

While many previous studies have been prompted by ad hoc reports of somatically focused syndromes such as Gulf War Syndrome, or by concern about specific chemical and other hazards, such as Agent Orange in Vietnam [1], the MEAO Prospective Study focused on a range of candidate health outcomes which were identified as relevant by the Institute of Medicine [2] in the review of the literature following the Gulf War 1990-91.

The MEAO Prospective Study also employed a prospective methodology in order to capture the trajectories of symptoms and the underlying biological mechanisms of the health outcomes of specific interest over time [3]. Data was collected immediately prior to deployment (baseline) and then again approximately four months post-deployment which greatly reduced the potential for recall bias often seen in many other studies. A major strength of this methodology was that it also allowed for individuals to act as their own control, overcoming the need to identify a matched control group.

Many of Australia's coalition partners have also used a longitudinal methodology to better understand the health outcomes from deployment; however, the MEAO Prospective Study is the **only longitudinal Australian study** which has done so. Furthermore, the MEAO Prospective Study is the only study to collect both objective and self-report data on such a **wide range of mental**, **physical and social health** indicators from deployed military personnel. An understanding of these issues is vital to both Defence and the DVA to ensure that they have the capacity and health systems in place to meet the emerging needs of the MEAO cohort.

22.1 The Findings

While there were changes between pre- and post-deployment for the health outcomes considered in this report from an epidemiological perspective, the majority of individuals who responded to the MEAO Prospective Study were psychologically, physically and socially healthy before and after deployment. For example, three quarters of respondents had low psychological distress and over 90% met the criteria for low depressive symptoms and minimal PTSD symptoms, at pre-deployment. There were shifts between pre- and post-deployment, however, the majority of participants were still considered to be at a low or minimal risk for all three psychological disorders at post-deployment. Yet there was a small but important sub-group of individuals who were found to be either at risk of future adverse health outcomes or alternatively, had already reached clinically relevant morbidity.

This pattern of little overt morbidity in the majority of participants was also repeated for the physical health measures. For example, only a minority of participants reported a lifetime or newly acquired mTBI. In addition, the majority fell within the normal range for all of the cardiovascular indicators and had a normal lung function based on their age and height at both pre- and post-deployment. Of particular interest however, was the lower than expected incidence of infectious disease, once again at both pre- and post-deployment. Leishmaniasis [4] and Hepatitis C [5], which are known to be prevalent in the military personnel deployed by Australia's coalition partners, were not found in any of the respondents in this study at either pre- or post-deployment. In addition, in stark contrast to other military studies [6-8], there was no evidence of significant changes to the skin conditions of these respondents resulting from the most recent deployment. Together, these findings suggested that the protective health measures employed by Defence have been effective in a number of domains.

It was expected that the MEAO Prospective Study sample would prove to be particularly healthy for a number of reasons. First, initial recruitment selection already ensures a relatively health workforce in comparison to the general Australian population. However, the additional health checks that are required prior to deployment ensure that this sample would comprise of some of the fittest members of the ADF. Second, it should be remembered that post-deployment data collection occurred on average four months after returning from deployment and, therefore, some deployment related disorders may already have been effectively treated.

22.1.1 Clinical Significant Findings

Some clinical significant findings were, however, found (Table 22.1) at both pre- and post-deployment. This suggested that the current process for screening military personnel before they depart and then again on return to Australia do not capture all health issues. This finding supports the need for continued improvements to both the pre- and post-deployment operational screening.

Table 22.1: Clinical significance of findings pre- and post-deployment

Psychological Distress

2.5% of the sample at pre-deployment and 4.8% of the sample at post-deployment were above the epidemiological cut-off [9] which suggests they would meet the criteria for anxiety or affective disorder.

PTSD Symptoms

0.1% of the sample at pre-deployment and 1.9% of the sample at post-deployment were above the epidemiological cut-off [9] which suggests they would meet the criteria for PTSD.

Alcohol Usage

1.0% of the sample at pre-deployment and 2.5% of the sample at post-deployment scored above the epidemiological cut-off for [9] which suggests they would meet the criteria for an alcohol disorder.

Suicide Ideation

0.7% of the sample at pre-deployment and 1.6% of the sample at post-deployment reported suicidal ideation. As a duty of care, these participants were contacted by an ASIST trained research staff member to ensure that they had or were receiving appropriate care (Appendix H)

Cardiovascular Risk

11.1% of the sample at pre-deployment and 14.9% of the sample at post-deployment were obese based on the waist to hip ratio and 1.1% of the sample at pre-deployment and 1.6% of the sample at post-deployment had hypertension.

Lung Function

4% of the sample at pre-deployment and 4.5% of participants at post-deployment met the Global Initiative for Chronic Obstructive Lung Disease criteria. As a duty of care, these participants were personally notified of the finding and advised to seek further medical advice (Appendix K).

Another result of clinical interest pertained to a decrease in sero - prevalence between pre- and post-deployment for IgG titre measures in the Herpes family of viruses. These findings may be indicative of the impact on immuno-competence. However, due to this shift in the host/agent equilibrium, there is a greater risk of these viruses following deployment. Potentially, these changes will have an impact on cognitive function as well as somatic symptoms and therefore require further investigation.

22.1.2 Sub-Syndromal Shifts

In addition to these findings of clinical concern, there were also a number of statistically significant changes between pre- and post-deployment which adds weight to the growing body of literature which suggests that repeated exposures to trauma over a prolonged period increases the risk of psychological morbidity in the future [10]. It may therefore be prudent to continue to follow-up personnel who have been on deployment and who have reported any of the following exposure and risk factors.

22.2 Exposures and Risk Factors

Sub-syndromal shifts were statistically significantly associated with a number of factors related to the most recent deployment. Supporting the first hypothesis, combat was significantly associated with post-deployment psychological and some physical dys-regulation.

22.2.1 Combat Role or Operating Outside of the Main Support Base

Changes to both physical and psychological health were associated with the role on the most recent deployment. Specifically, increases in psychological distress, depressive symptoms, PTSD symptoms, alcohol use and number of somatic symptoms were greatest or more likely for those who operated in a combat role or who were based outside of the main support base. In addition, being in a combat role or operating outside of the main support base in Afghanistan was also associated with experiencing a new mTBI at post-deployment and decreases in cardiovascular fitness between pre- and post-deployment. This has implications for targeting current screening processes in the ADF and for high risk groups that could be identified for the most intensive follow-up at point of discharge, as they move into the veteran community.

22.2.2 Traumatic Deployment Exposures

In line with the first hypothesis, both the number and type of traumatic deployment exposures were associated with decreased physical and psychological health between pre- and post-deployment. For example, higher numbers of traumatic deployment exposures were associated with increases in psychological distress, depressive symptoms, PTSD symptoms, alcohol use and somatic symptom reporting. In addition, higher numbers of traumatic deployment exposures were also associated with the reporting of a new mTBI at post-deployment and decreases in cardiovascular fitness. Reports of being in a vulnerable situation or in fear of an event, unable to respond to a threatening situation and human degradation were associated with increased in psychological distress, depressive symptoms, PTSD symptoms, alcohol use and somatic symptoms. These exposures were similar to those identified in the 2010 ADF Mental Health Prevalence and Wellbeing Survey [9] as being associated with the greatest risk of PTSD. This finding demonstrates the importance of recording traumatic deployment experiences, which have shown to be an effective predictor of psychological morbidity. It also has implications for the future of clinical screening undertaken during deployment as well as those conducted prior to and immediately after returning to Australia.

22.2.3 Longer Lengths of Most Recent Deployment

In general, being away for longer periods of time tended to be associated with changes to a number of self-reported health measures. Specifically these included increases in psychological distress, PTSD symptoms, alcohol use and somatic symptoms. A longer length on the most recent deployment was also associated with reports that either the participant or their partner had seriously contemplated a divorce or permanent separation. In addition, there were also a number of associations with changes to the objective measures of physical health including increases to BMI, blood pressure, as well as decreases to cardiovascular fitness as measured by the Queens College Step Test.

Surprisingly, the association between longer length of most recent deployment and increased psychological and somatic symptom reporting was not completely consistent. In particular, while participants who were away for six to seven months and nine to twelve months were more likely to report increased in psychological distress and somatic symptoms; this was not the case for those away for eight months. Likewise, those participants who were away for six to seven months and nine to twelve months were more likely to have co-morbid psychological conditions, in comparison to those away for five or less months. However, this was not the case for those who were away for eight months.

These findings suggested that those participants who were away for eight months were different to the participants who were away for six to seven months and nine to twelve months. Rather than being an effect of time on most recent deployment, it is more probable that these findings are associated with demographic factors and/or deployment experiences. For example, it is possible that these participants were younger and on their first deployment. Another potential explanation is that the participants who deployed for eight months primarily belonged to a unit that functioned differently to other units. In order to test these hypotheses further investigation is required which is beyond the scope of this report.

22.2.4 Prior Deployment Experiences

Lifetime mTBIs reported at pre-deployment and perceived problems with their children on the most recent deployment were the only health outcomes which were associated with any of the prior deployment experiences (number of prior deployments, time away on prior deployments in the past three years and prior combat exposure). While the lifetime mTBIs appears to be consistent with previous studies [11], the second finding, at first glance appears to be counter intuitive. However, a number of potential explanations have been posited within Chapter Eighteen, including that ramifications from previous deployment experiences increase the participant's level of concern for their children who are left behind. One of the issues in discussing these data is that those with overt adverse consequences of previous deployment will not pass the medical selection criteria prior to the next

deployment. Hence the effects of multiple deployments will be underestimated because the study did not include those members who had failed to meet the predeployment selection criteria.

22.3 Psychological Co-morbidity

As well as sub-syndromal increases in both physical and psychological health outcomes between pre- and post-deployment, the study findings also identified a group of participants who at post-deployment were at risk of psychological morbidity. In total 214 participants were considered to have a number of co-morbid conditions based on the ADF screening criteria [12]. Specifically, 73 participants met these criteria for three psychological conditions being psychological distress, PTSD symptoms and alcohol use and 141 participants met the criteria for two of the conditions. In support of the second hypothesis, the majority (62.3%) of respondents who had three co-morbid disorders at post-deployment also met the ADF screening criteria for at least one psychological condition at pre-deployment.

This finding suggests the limitations of pre-deployment self-reported medical assessments due to the potential that members are not motivated to correctly disclose the symptoms that they may be faced with. Conversely this finding also importantly identifies that approximately one third of participants reported no symptoms at pre-deployment, yet still developed clinically relevant psychological morbidity by the time they returned home to Australia.

In addition, the analyses of this co-morbid group, in comparison to those participants with none or only one other psychological disorder, identified a unique set of associations indicative of the risk factors for high levels of distress (Table 22.2).

Table 22.2: Summary of associations with co-morbid psychological conditions at post-deployment.

Length of Most Recent Deployment

Those participants who were deployed for longer periods on the most recent deployment were more likely to have psychological co-morbidity at post-deployment.

Traumatic Deployment Exposures

Those participants who reported a very high number of traumatic exposures on their most recent deployment were more than twice as likely to have two or more co-morbid conditions. In addition, people with two or more co-morbid conditions were significantly more likely to report each of the traumatic deployment exposure categories than those with none or only one psychological condition at post-deployment.

Somatic Symptom Reporting

A greater proportion of participants who had two or three co-morbid conditions at postdeployment reported each of the top 15 most commonly reported somatic symptoms.

New mTBIs

Respondents with two or three co-morbid psychological conditions at post-deployment were significantly more likely to also have reported a new mTBI at post-deployment.

Personal Relationships

Participants with two or three co-morbidities at post-deployment were more likely to report a decrease in their relationship satisfaction between pre- and post-deployment and to report that they or their partner had considered divorce or permanent separation since the beginning of the most recent deployment. In addition, these respondents were also less likely to perceive that they received sufficient support while on deployment from either their family and/or partner.

Relationships with Children

Respondents with two or three co-morbid psychological conditions at post-deployment were significantly more likely to perceive that their military career had negatively impacted their children.

Tobacco Usage

Participants who began or restarted smoking on the most recent deployment, as well as those who started smoking while on the most recent deployment were more than twice as likely to have at least two co-morbid psychological conditions at post-deployment.

Prior Life Traumas

Those respondents who reported five or more prior life traumas at pre-deployment were more than twice as likely to meet the criteria for two or three co-morbid conditions at post-deployment.

These psychological co-morbid groups require particular attention in terms of the possibility that their health will continue to deteriorate. Methods of better targeting, detecting and diagnosing this group need to be considered. In particular, the effectiveness of the post-deployment mental health screens in detecting this group requires evaluation.

22.4 Potential Risk Markers

Contrary to all of the findings summarised above, neurocognitive assessments have **clearly identified a prior deployment effect which supports the third and final hypothesis investigated by this initial study**. Similar to another recently published study [13], evidence of a continuing neural signature of increased arousal and decreased efficiency was found in participants who had reported prior deployment experiences.

In particular, qEEG results demonstrated that even the first deployment may result in changes to resting state brain activity. In particular, qEEG has identified findings which suggest that the number of prior deployments and the total months deployed in the previous three years are both associated with a change in alpha rhythms which

suggests an increase in visual hyper-alertness. Perhaps even more importantly, these increases remained stable over subsequent deployments. These findings suggest increased cortical arousal at times when the brain should be able to be at rest.

Additionally, qEEG results with eyes open, which tests the ability to attend to environmental signals, found that prior combat exposure was associated with increased alpha in the centro-parietal regions. This finding may suggest disruption of the working memory function, which could be linked to changes in working memory updating associated with aspects of deployment. Furthermore, this increased alpha in the frontal regions is thought to be associated with clinical arousal, and potentially a marker for future dys-regulation. Importantly, these changes once they occurred appeared to be stable between deployments, rather than returning to baseline during post-deployment resting periods. In essence, deployment experience leaves a neural signature of increased arousal and decreased efficiency of working memory processes.

Related changes in neurocognitive functioning associated with prior deployments were also identified from analyses of the working memory paradigm data. Results indicated, for example, that both the effort required and the time taken to update working memory was significantly different according to whether the participant had prior combat experience and according to the number of prior deployments. In addition, the length of the most recent deployment and the number of traumatic exposures reported for the most recent deployment were also associated with changes in working memory function.

Despite 13.8% of the entire pre- and post-deployment sample having reported prior combat exposure and well over half of the sample (57.7%) having been on at least one previous deployment, analyses of the self-report data did not find any association between these factors and changes to psychological symptoms. Participants, particularly if they are concerned about their ability to deploy, could choose not to accurately report any symptoms they may be experiencing. Therefore, objective measures such as the neurocognitive assessments used in this study may prove to be better measure of changes to cognitive and psychological functioning [14, 15]. Importantly, there were a number of other neurocognitive paradigms (Emotional Processing, Response Inhibition and Startle) which were collected but could not be analysed within the timeframe.

One potential use for these neurocognitive assessments could be the objective identification of mTBIs. Although not considered in this study, previous research has already provided evidence that EEG, for example, is able to detect diminished neural functioning in participants who have incurred an mTBI [16], and more importantly, discriminate between mild and severe traumatic brain injuries [17]. Given the number of participants who perceived that they had incurred a new mTBIs since the beginning of their most recent deployment (9%) the development of an accurate screening tool which detects any residual effects including cognitive changes and any related psychological disorders such as PTSD, would be of considerable benefit. Objective evidence would ensure that personnel receive appropriate treatment and support, if required. The data also have a substantial capacity to accurately inform the debate pertaining to post-deployment syndromes including mTBI that currently exists.

Contrary to the hypothesis, the initial analysis of allostatic load, another promising objective measure of future risk for morbidity and/or mortality, was not conclusive. However, there are a number of potential reasons for this. First, ceasing to collect the saliva samples for adrenaline, nor adrenaline and cortisol meant that these measures which have consistently been included in other studies of allostatic load were not available. Second, a basic cumulative model was used to calculate the allostatic load score and, given the relatively health sample in this study, it may be necessary to consider a more sophisticated method such as latent class analysis. However, this type of analysis was well beyond the scope of this report.

22.5 Limitations

One of the major limitations to be acknowledged is that the scope of this report did not allow for the in-depth analyses warranted by such an extensive and valuable database. In particular, two of the five hypotheses were not investigated as they were beyond the scope of this particular report.

- 1. The range of non-specific symptoms typically associated with postdeployment syndromes (somatic symptoms) will predict the degree to which underlying biological systems are dys-regulated; and
- 2. the range of psychological symptoms will also predict the degree to which underlying biological systems are dys-regulated.

It is important to note that the purpose of this study was not to measure the prevalence of psychological, physical or social health morbidity within the deploying population. In particular, the study did not have access to all eligible deploying personnel at either pre- and/or post-deployment. Therefore, some caution should be applied when interpreting the findings. In addition, some participants did not complete all parts of the data collection and therefore in some instances sample sizes were further reduced for the analyses of some health outcomes.

While there are differences between the various sub-groups within this deploying population, the purpose of this report was not to identify these differences. In particular, small numbers in some of these sub-groups may have meant that there was not sufficient power to detect statistically significant differences.

It should also be acknowledged that the reported psychological symptoms including those that met the criteria for two or more psychological conditions at post-deployment were all based on self-report data. In order to more accurately identify mental disorders in this sample the Composite International Diagnostic Interview (CIDI) should have been used.

22.6 Support for the Hypotheses

The initial analysis of the extensive MEAO Prospective Study database supports all of the three hypotheses.

1. Combat exposure or operating outside of the main support base was found to primarily be associated with post-deployment psychological dys-regulation in individuals who had little or no evidence of significant psychological dys-regulation prior to deployment.

- 2. Prior trauma exposure and other lifetime experiences were significantly associated with psychological co-morbidity at post-deployment, particularly in the case of those participants who were found to have three psychological conditions at post-deployment.
- 3. The number and time away on previous deployments were significantly associated with shifts in cognitive functioning, and these deployments left evidence of continuing neural signature of increased arousal and decreased efficiency.

Finally, it was always intended that these findings provide the baseline for monitoring health outcomes into the future and that this study is the beginning of an investigation into how deployment exposures modify the risk of potential morbidity in the deployed military population.

22.7 Further Analyses

The MEAO Prospective Study has collected an extensive dataset on the health of deployed personnel. To do justice to the national and international significance of this dataset further analyses are required.

First, it is important to undertake the analyses of the following primary areas of interest which due to time constraints could not be included in this report:

- Neurocognitive assessments Working memory
- Neurocognitive assessments Startle
- Neurocognitive assessments Response inhibition

Second, also due to time constraints an investigation of the associations between the presence of the following conditions at pre- and/or post-deployment is still required.

- Skin conditions
- Infectious diseases
- Abnormal biochemistry results

Third, while extensive analyses of the associations between changes to health outcomes and deployment exposures was presented in all other chapters of this report, analyses of the moderators and/or mediators that may impact on these associations are still required.

Finally, questions which need to be addressed are presented at the end of Chapters Five to Twenty One. These are specific to the focus of each chapter and relevant to gaining a better understanding of changes to health outcomes as a result of a military deployment experience.

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