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- Predictors of Depression Diagnoses and Symptoms in United States Female Veterans: Results from a National Survey and Implications for Programming
- The Effects of Hippotherapy on Motor Performance in Veterans with Disabilities: A Case Report
- Joint Expeditionary Medical Support in 1914: The US Occupation of Veracruz, Mexico

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Front Cover: Corporal Wayne Doolan Gives a Young child from a local Baucau crache a dose of medicine to help with an illness.© Department of Defence

Journal of Military and Veterans' Health

Australasian Military Medicine Association

STATEMENT OF OBJECTIVES

The Australasian Military Medicine Association is an independent, professional scientific organisation of health professionals with the objectives of:

- Promoting the study of military medicine
- Bringing together those with an interest in military medicine
- Disseminating knowledge of military medicine
- Publishing and distributing a journal in military medicine
- Promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine. The Association is totally independent of the Australian Defence Force.

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Editorial

Back in early June, the Navy Health Reserve was asked to provide some health staff for an Army exercise, Exercise Hamel, to be held at the end of June 2016. In itself, this request was nothing unusual; such requests for support of military operations and exercises are frequent. What was interesting is that I had no clear idea as to what or who Hamel was, although I am sure many of my Army colleagues could have enlightened me.

Ninety-eight years ago, on 04 July 1918, the Australian 4th Division of the Australian Imperial Force, supported by the Australian 11th and 16th Brigades, British 5th Tank Brigade and four companies of the U.S. 56th Brigade carried out a successful attack against German positions in and around the town of Le Hamel in northern France during World War I. The battle was planned and commanded by Lieutenant General John Monash, who using a combined arms attack, achieved all of his objectives in 93 minutes, just three minutes longer than he calculated. Allied losses were 1,062 Australian casualties (including 800 dead) and 176 American casualties during the main attack. Around 2,000 Germans were killed and 1,600 captured, along with the loss of much of their equipment and a large quantity of British equipment that they had been captured in April. Two Australians, Thomas Axford and Henry Dalziel, were awarded the Victoria Cross for their actions during the battle.[1]

While small in scale, the combined arms tactics used in the Battle of Hamel proved to be very useful against entrenched troops and would be used successfully in larger battles, such as the Battle of Amiens, later in the war. It was also the first time that American troops participated in an offensive action under non-American command, although General Pershing set out explicit instructions after the battle to prevent further such use of US troops.[2]

Our third issue of 2016 addresses a range of diverse areas. Malaria, as both a maritime and operational threat, is addressed in two excellent articles. There is also a focus on veterans' health, with articles on predictors of depression, reproductive health, men's health and the utility of hippotherapy in veterans. Finally, there is an interesting historical article on medical support to the U.S occupation of Veracruz, Mexico, in 1914.

We continue to get a good range of articles, but other military and veterans' health articles are always very welcome and we would encourage all our readers to consider writing on their areas of military or veterans' health interest. Our themes are now available for both 2016 and 2017 to allow for authors to research and develop their articles – we certainly welcome articles in these areas but welcome any articles across the broader spectrum of military health. We would also encourage authors who are preparing to present at the AMMA Conference in October to consider writing up their presentations for publication in the Journal.

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

1 *Carlyon L. The Great War. Pan Macmillan; Sydney:2006.*

2 *Coulthard-Clark C. Where Australians Fought: The Encyclopaedia of Australia's Battles (1st ed.). Allen and Unwin; St Leonard's, New South Wales: 1998.*

Predictors of Depression Diagnoses and Symptoms in United States Female Veterans: Results from a National Survey and Implications for Programming

K. H. Thomas, D. L. Albright, M. M. Shields, E. Kaufman, C. Michaud, S. Plummer Taylor, K. Hamner

Abstract

Background and Purpose: Research suggests that female veterans of the United States military are more likely than their male counterparts to report mental health concerns such as posttraumatic stress, depression and suicidal thoughts. The purpose of this study was to explore the interaction of service era (time period during which active duty service occurred), social support, and beliefs about mental health care utility as they relate to depression in female veterans in the hope of improving health programming for this priority population.

Materials & Methods: Secondary analysis of data from the 2012 Behavioral Risk Factor Surveillance Survey (BRFSS) conducted by the Centers for Disease Control and Prevention (CDC) involved logistic regression analysis of a large, nationally-sourced sample of 54,060 veterans, of whom 8.5% were women (n = 4,544). Correlations were found between social support, service era, and treatment stigma variables as they predicted outcome variables of diagnosed and undiagnosed depression.

Results: Of the nationally-sourced sample of 4,544 female veterans, 25.5% reported a medically-diagnosed depression condition of mild, moderate, or major severity. Of veterans in the sample who did not already have a depression diagnosis, 12% indicated the presence of symptoms that indicate undiagnosed depression of mild, moderate, or major severity. Female veterans from recent wars in Iraq and Afghanistan were more likely than older peers to be struggling with symptoms that may indicate undiagnosed depression or to have a depression diagnosis.

Conclusion: The findings of this study aided in identifying three demographic and behavioural health predictors of diagnosed depression and one predictor of undiagnosed depression in the female military veteran population that demonstrated both practical and statistical significance.

Keywords: military, mental health, veteran, veterans' health, women's health, female veterans, warrior culture, stress, posttraumatic stress, depression, suicide, resilience, programming.

Background

Suicide is a major health problem in the military community, and depression and stress injuries are known contributors to this public health problem.[1] Conservative estimates indicate that the numbers of suicide attempts and completions have increased since 1995, and are currently hovering at 22 veterans taking their own lives each day, along with one active duty service member per day.[2] Suicide risk is almost four times higher in the veteran population than in non-veterans1. Military deployment to a war zone elevates the risk of long-term physical, psychological, and social problems and reduces overall health.[3] In addition, reintegration into new roles and loss of community felt when leaving the military contribute to depression among recently discharged veterans.[4] As the United States completes troop drawdowns in Iraq and Afghanistan, the mental health ramifications for the all-volunteer military are an important concern for health professionals.[5] Research has shown that female veterans are six times more likely to commit suicide than civilian women. Rates seem to be higher among younger veterans between the age ranges of 18-29; they are twelve times more likely to commit suicide than non-veterans.[6] The purpose of this study was to examine the relationship between three

key predictor variables (service era, relationship status, and opinions about mental health treatment) and rates of diagnosed depression and symptoms indicating undiagnosed depression in a national sample of female military veterans in order to generate predictive models for the condition in women who have served.

Women constitute approximately 15% of the armed services and represent a growing segment in the veteran population.[7] Female service members and veterans have complex healthcare needs.[8] Studies indicate that female veterans returning from deployment are more likely than their male counterparts to report mental health concerns such as posttraumatic stress (PTS), depression, and suicidal thoughts.[9-10] Koo (10) reported that women were more likely to screen positive for depression both before and after deployments.

Targeting programs towards women must take into consideration several facets of the female military experience that differ from their male counterparts. Women are more likely to face issues of discrimination and belonging, and are at a disproportionately high risk for Military Sexual Trauma (MST). MST is under-studied and under-reported, but between 20-40% of female veterans report experiencing MST during their time in service.[11] During mental health screenings, one in five women report MST, which is sexual violence and defined as sexual coercion, sexually threatening behaviour, and/or sexual assault experienced during their military service.[12] Additionally, the majority of female veterans report having endured ongoing sexual harassment.[13-14] Historical discrimination against women in the service branches combined with cultural issues that linger in the present day can make issues of social support and unit cohesion uniquely salient for military women.[15-16] Many servicewomen report feelings of alienation and decreased feelings of unit cohesion while serving.[17] These women are at increased risk for mental health problems, including depression and PTSD.[18]

Suicide is positively correlated with depression, of which stress and anxiety are symptoms.[5,19-20] Depressive conditions are closely related to trauma and stress-related disorders like PTS; the two often co-occur.[21-22] Depression in veterans can be categorised as both diagnosed and undiagnosed.[20] Statistics on PTS in veteran communities are uncertain, with estimates out of the Veteran's Administration sitting at 15-50%.[23] A RAND corporation study reported numbers hovering at about 20%.[24]

Resilience is the ability to become strong, healthy, or successful again after something stressful happens. Military service is stressful for a variety of reasons, from deployments, family stress, and transitions from active duty to civilian status in a community where only a small percentage of the population has served.[22-23] The relationship between exposure to traumatic stressors and poor post-service health is well documented.[22] Still, some individuals are more psychologically resilient than others, and increasing understanding of resilience within given communities and populations may help target programming.[25] Case studies of existing programs that have worked to build resilience in different populations provide the foundation upon which savvy programmers must build; and health promotion professionals working to prevent and treat mental health problems like depression and stress illness must understand the confluence of warrior culture and mental health issues in the veteran community.[14,26]

Method

Study Design and Sample

The research team coded data from the 2012 Behavioral Risk Factor Surveillance Survey (BRFSS), which is conducted by the Centers for Disease Control and Prevention (CDC) annually; it is administered via telephone across the country by state health departments. The BRFSS inquires about a number of demographic, health, and behavioural issues and provides comprehensive analysis opportunities for a broad range of health topics.[27]

Data from veteran respondents were extracted from the BRFSS survey at large. The resulting respondent pool included a large, nationally-sourced sample of 54,060 veterans, of whom 8.5% were women (n = 4,544). This percentage closely aligns with national estimates that women comprise 10% of the American veteran population.[28-29]

Study Variables

Covariates. Predictor variables were chosen to highlight the ways in which age, social support, and opinions about mental health care impact the mental health of women who have served in the military.

Age. Veterans were grouped into service eras according to their age in Bureau of Labor Statistics tabulations, because Department of Defense manpower numbers indicate that most service members fall within a given demographic age range.[28] Recoding age involved taking the BRFSS continuous age variable and assigning it to categories. Veterans serving in the most recent conflicts in Iraq and Afghanistan are those between the ages of 18-34, and were coded Operations Enduring Freedom and Iraqi Freedom (OEF/OIF). These data also include veterans who

served during Operation New Dawn, the American operations in Iraq after 2010. Respondents between the ages of 35-55 were assigned the Gulf War era category, veterans 55-78 years were assigned to the Vietnam era, and over 78 years to Korea.[20] Veterans' experiences in a given era are coloured by the conflict that dominated their time in service and the government resources and policies prevalent during service and the transitory period immediately after leaving.[30]

Relationship Status/Social Support. A BRFSS question asking about marital status and partner relationships provided insight into the social support a respondent enjoys. Social relationships play an important role in promoting better health and alleviating diseases.[14,31] While not all kinds of social interactions produce similar health consequences, intimate partnerships are considered a reliable indicator of social support.[32-33] Some female veteran respondents had close partnerships while others did not, making possible analysis of relationship status (which indicates social support) as a predictor of veteran depression. Participants were classified as partnered or non-partnered.

Stigma Against Mental Health Care. Of particular interest was a question asking respondents to offer opinions on the usefulness of seeking mental health care. This question sheds light on issues of patient-stigma in the veteran population.[34] Many veterans feel that care-seeking is a sign of weakness, is not useful, or that care providers do not understand their needs.[5,26] The BRFSS assesses respondents' attitudes about the effectiveness of mental health care, asking specifically in Question 9 of Module 17 whether the respondent believes such care can be positive and helpful. It asks respondents to agree on a scale with the statement "treatment can help people with mental illness lead normal lives." To simplify the categories for analysis, the variable was recoded to include all respondents that are answering to agree strongly or slightly as 'yes' responses, all disagreeing slightly or strongly, or neutrally as 'no' responses. Researchers have found that contact with the existing care system impacts opinions, and veterans with symptoms indicating undiagnosed depression may also suffer from negative beliefs about mental health care in general.[35-36]

Depression. The research team coded two outcome variables. A BRFSS question asking specifically whether a respondent had ever been diagnosed with depression of any severity level provided an outcome variable indicating medically-diagnosed depression. In order to broaden the utility of analyses, this study also sought indicators of depression that could be coded to indicate undiagnosed cases of depression in respondents. A question in the 2012 BRFSS addressed symptom presence and offered sufficient responses to present statistically useful possibilities. This continuous variable was recoded to eliminate respondents who were already medically-diagnosed with a depressive condition. Respondents that were coded as "yes" included those who answered whether undiagnosed depression may be present. Question 2.2 specifically asks, "thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" Self-reported symptom presence anywhere from 5-30 days was coded to indicate the presence of symptoms that may indicate undiagnosed depression. Previously-diagnosed respondents were dropped to simplify analysis, leaving 3,385 cases.

According to the Adult Severity Measure for Depression (PHQ-9) from the American Psychological Association, variables indicating depression of mild, moderate, or major severity include both the frequency of depression symptoms and the presence of feelings like nervousness, hopelessness, restlessness, depression, low interest in normal activities, and/or feelings of worthlessness as well as the severity of perceived poor mental health.[21,37] Depression symptoms are varied and present themselves differently in each individual, so perception of overall poor mental health is a useful indication of undiagnosed depression.[38] Self-report of symptoms is a common method for diagnosing depression in clinical settings, and grouping mild, moderate, and major levels of symptom presence together invited comparability with the variable indicating diagnosed depression, which also grouped severity levels together.[39]

Data Analysis

All assumptions for logistic regression were checked and data were analysed using the Statistical Package for the Social Sciences (SPSS) version 23 for Mac.

The independent variables were tested and logistic regression modeling demonstrated that diagnosed depression was significantly related to all predictor variables including: service era, relationship status, and beliefs about mental health care using a threshold of $p < .05$.

To provide macro-level practical significance information, crosstab analysis checked for the practical significance of independent variables on dependent variables.[40] Correlations resulting from univariate logistic regression analysis then screened the effect of these independent variables (service era, relationship status, and beliefs about mental health care) on dependent variables including: diagnosed

depression and symptoms indicating undiagnosed depression. Significance levels were set a priori at p < .0541-42.

Results

Descriptive statistics were calculated for all predictor variables (see Table 1). Of the nationally-sourced sample of 4,544 female military veterans, 48.8% were partnered, with 51.2% having less social support in a non-partnered status. Six hundred and forty-five served during the OEF/OIF era (14.2%); 1,935 served during the Gulf War era (42.6%); 1,509 served during the Vietnam War era (33.2%); and 455 served during the Korea War era (10.0%). Almost all female veterans (95.8%) held a negative view of mental health treatment and its usefulness for an individual (male or female) in mental health distress.

Logistic regression analysis explored linkages between two depression variables in female veteran respondents: diagnosed depression and undiagnosed depression, predicted by service era, relationship status, and beliefs about mental health care's usefulness.

For the outcome variable of diagnosed depression, all three variables were statistically significant (p < .001). Predictor variables that were both statistically significant and important to the individual in terms of effect (odds ratios of 1.5 or higher) were not found. However, relationship status was high with an odds ratio of 1.310 (see Table 2).

Table 1 Summary of Predictor Frequency Statistics for Sample of Female Veteran Respondents

Variable	n	%
Veteran Service Era	4544	
• Operations Enduring/Iraqi Freedom	645	14.2%
• Gulf	1935	42.6%
• Vietnam	1509	33.2%
• Korea	455	10.0%
Relationship Status	4544	
• Partnership	2219	48.8%
• No partnership	2325	51.2%
Beliefs About Mental Health Care	4544	
• Favourable	193	4.2%
• Unfavourable	4351	95.8%

The variable coded to show symptoms indicating undiagnosed depression was significantly related to the variable of service era using a threshold of p < .05 while relationship status and beliefs about mental health care were not. The service era variable was both statistically significant and important to the individual in terms of effect; veterans of OEF/OIF were 3.62 times more likely than the reference category of Korean War veterans to be displaying symptoms that may indicate undiagnosed depression (see Table 3). This category was chosen as a reference because it was the smallest in terms of respondent representation and female veteran representation.

Table 2 Univariate Logistic Regression Analysis of Predictor Variables: Diagnosed Depression

Variable	B	SE	Odds Ratio	95% CI	P	% Variance Nagelkerke
Veteran Service Era (likelihood of 'yes' diagnosis)			n/a		< .001	2.7%
• Operations Enduring/Iraqi Freedom*	-.887	.181	0.412	.289, .587	< .001	
• Gulf	-1.253	.162	0.286	.208, .393	< .001	
• Vietnam	-1.192	.164	0.304	.220, .419	< .001	
• Korea						
Relationship Status	.270	.068	1.310	1.145, 1.498	< .001	0.5%
• Likelihood of 'yes' diagnosis for Non-Partnered						
• Likelihood of 'yes' diagnosis for Partnerships						
Beliefs About Mental Health Treatment	-2.901	.202	0.055	.037, .081	< .001	9.8%
• Likelihood of 'yes' diagnosis for Favourable						
• Likelihood of 'yes' diagnosis for Non						

**Odds ratios from univariate regression with smallest category as reference (Korea)*

Table 3 Univariate Logistic Regression Analysis of Predictor Variables: Symptoms Indicating Undiagnosed Depression

Variable	B	SE	Odds Ratio	95% CI	P	% Variance Nagelkerke
Veteran Service Era (symptom presence)			n/a		< .001	3.5%
• Operations Enduring/Iraqi Freedom*	1.285	.224	3.615	2.329, 5.610	< .001	
• Gulf	.718	.211	2.050	1.355, 3.103	.001	
• Vietnam	.208	.196	1.231	.793, 1.911	.354	
• Korea						
Relationship Status	-.137	.106	0.872	.709, 1.073	.196	0.1%
• Symptom presence for Non-Partnered						
• Symptom presence for Partnered						
Beliefs About Mental Health Treatment	-.206	.611	0.814	.246, 2.695	.736	0.0%
• Symptom presence for Favourable						
• Symptom presence for Non						

**Odds ratios from univariate regression with smallest category as reference (Korea)*

In univariate analysis, the percent of variance explained by each variable was small, though statistical significance existed between all independent variables and diagnosed depression (Nagelkerke R2 = 0.5-9.8%) with all cases correctly classified. Statistical significance existed between the service era variable and symptoms indicating undiagnosed depression (Nagelkerke R2 = 3.5%). With an alpha level greater than 0.05, the variables of relationship status and opinions on mental health treatment both lacked significance. Researchers also noted models were fit for both diagnosed depression (χ^2 (DF, N = 5) = 460.259, $p \leq .001$) and symptoms indicating undiagnosed depression (χ^2 (DF, N = 5) = 71.473, $p \leq .001$).

Discussion

Gaining a better understanding of depression in the veteran population is vital to health promotion programming in the military community and to suicide prevention efforts.[19,34] A number of studies have attempted to explore the issue of depression and PTS in women veterans, but ranges and rates vary widely and predictive models that could guide program decisions are lacking.[43-45] The findings of this study aid in identifying demographic and behavioural health predictors of depression (both diagnosed and undiagnosed) in the female military veteran population. Such findings can be used to support programming aimed at reducing suicidal ideations, attempts, and completions.

Limitations

When considering the findings of this exploratory report, a number of limitations must be acknowledged. Secondary analysis of 2012 BRFSS survey data, while providing a large, randomly-selected sample of veteran respondents, limited the scope of questions that could be asked about predictive variables and veteran depression. The sample was delimited to veterans not in institutions, homeless, or those who had already completed suicide attempts, which potentially resulted in an under-representation of depression rates in veterans. Data were self-reported, which could be problematic due to respondent recall or reluctance to truthfully answer sensitive, personal questions. However, the use of self-report in survey-based research in the field is both accepted and common.[46]

The variable of veteran service era is limited. Veterans are grouped into service eras according to their age in Bureau of Labor Statistics tabulations, because Department of Defense manpower numbers indicate that most service members fall within a given demographic age range. Seventy-two percent of service members are between 18 and 30 years old, and most serve only one four-year tour on active duty.[28] However, some veterans may fall into more than one service era.

While not all kinds of social interactions produce similar health consequences, intimate partnerships are considered a reliable indicator of social support.[32] However, a more recent study showed that family conflict and partner stress can lead to a reduction in adherence.[47] Also, in a study examining the benefits of marriage to the risk factors associated with cardiovascular disease, researchers found that marriage was not beneficial if the partners were dissatisfied.[48] This limits the utility of the relationship status variable as a method of defining

social support, specifically in female veterans who also deal with issues of discrimination and unit cohesion. Future research should more deeply explore social support in this sub-population.

Transitions are a Problem

Research suggests that both military-connected men and women have increased rates of interpersonal conflict and behavioural health risk within the first six months that they separate from the military.[49] Interestingly, the notion that deployment and combat trauma are the primary causes of stress injury and depression in veterans has been largely discredited by recent research.[50] A far more important predictor of such conditions appears to be the process of separating from service. Some difficulties that veterans have upon separating from the military include sharing their feelings, staying in touch with friends and their families, living in civilian society, pursuing and maintaining a job, taking care of all aspects of their health, and finding a sense of meaning in their life as a civilian.[22, 51]

Not only do veterans struggle with returning home, but their partners also struggle. The following statistics highlight the issue sharply: 83 percent of military spouses have feelings of anxiety and depression while their spouse is deployed, and 28 percent have difficulties with readjustment upon their spouse's return.[52] Military children also struggle with readjustment in various ways, which frequently includes increased levels of anxiety and behavioural problems at home and at school.[22, 51]

Depression is a Problem

The findings of our study support the broader research literature that the prevalence of depression is a significant problem for military-connected women.[53-55] Almost 26% of the female veterans in our study sample had a depression diagnosis, and an additional 12% showed symptoms of the undiagnosed condition.

It is important to include the service era of female veterans so that program developers and administrators are able to make efficient and data-driven decisions for targeted program development. The most likely female veterans to receive a depression diagnosis are of the OEF/OIF era followed by veterans of the Gulf War and Vietnam. Korean War veterans were the least likely to have a diagnosis. The most likely group to present symptoms that indicate undiagnosed depression included younger veterans of OEF/OIF, followed by veterans of Gulf War I and Vietnam. Korean War veterans were the least likely group to present symptoms. The findings indicated practical significance for veterans of OIF/OEF and suggested targeting interventions towards these younger groups.[56]

Relationship status was associated with diagnosed depression with both statistical and practical significance. Veterans not in partnerships (i.e., divorced, widowed, or single) were 1.3 times more likely than those in partnerships (i.e., married, cohabiting, or seriously-dating) to receive a depression diagnosis. These findings support the extant literature.

Social support is a known contributor to health and longevity, with recent studies indicating that high levels add 7.5 years to the average American life expectancy.[31,57] Studies have shown that there is an inverse correlation between lack of social support and increased depression symptoms, comorbid depression and anxiety, decreased scores for health measures, and more suicidal attempts reported specifically for homeless female veterans.[58] Many military service members are subjected to repeat deployments, which can result in compromised intimate relationships with spouses and children, gender shifts in role responsibilities, financial concerns, and diminishing community support.[59] The current study's finding is important because it suggests expanding the scope of programming to prevent depression beyond the current focus on social support at the unit level; it suggests a new urgency to family programming that is integrated and prioritised.

Gender norms in military family life must be considered in such programming. Approximately two million children have a military-connected parent or caregiver with many having deployed in support of OEF and/or OIF.[60] Research suggests that parental deployment is a risk factor for military-connected children and places them at higher risk for psychosocial problems than civilian children.[61] Parental depression may exacerbate those problems.[62] Given the dearth of school-based interventions to improve the well-being of military-connected children, many children do not have extra-familial supports and might be at increased risk with a depressed parent.[63] More research is needed on the impact of female service members' deployment, potential subsequent depression, and effects on the well-being of children and families.

Beliefs about the usefulness of mental health treatment were associated with diagnosed depression at statistically significant levels. Within the military community, much of the issue lies neither in lack of screening for depressive disorders, nor in the medical care available to service members suffering from depression. The problem is getting veterans to avail themselves of treatment services.[5, 64-66] Veterans who

held favourable views were slightly more likely to also have a depression diagnosis than those respondents who were undiagnosed. Previous research found that respondents who had received professional diagnoses were more likely to agree that mental health care was effective than undiagnosed peers; a smaller number of non-diagnosed respondents agreed that it was effective.[35]

Challenges in suicide prevention are many and include: stigma surrounding mental illness, negative perceptions of treatment, and concerns about confidentiality in the military setting. These challenges result in the majority of service members not accessing care when needed or dropping out prematurely.[66] Programming should consider cultural norms and recognise the issue of care-seeking stigma. Simply noticing that less than five percent of female veteran respondents somewhat or strongly agreed with the statement that mental health treatment could help a person is important; stigma is both strong and rampant in the culture of women warriors.

Female veterans face unique health issues related to rampant Military Sexual Trauma rates and a host of issues related to access to health care through the Veteran's Administration, both stigma-related and structural.[7] Easing access burdens for Department of Veteran Affairs (VA) benefits and health care must be a top priority; female veterans do not need additional barriers. Some of the available services that are offered through the VA are psychological assessment and evaluations, psychotherapy, inpatient and outpatient care, and psychosocial rehabilitation. There are several VA facilities that have established women-only programs and specialised women's treatment teams to serve those female veterans that are not comfortable in a mixed-gender environment.[7,67]

Enabling care access for younger female veterans is important. Older female veterans are more likely to access VA health care than their younger peers from Afghanistan and Iraq.[68] The largest sub-population of women that use VA services are between the ages of 45 and 64; women veterans that are 65 and older make up 14% of those that use VA services.[67] With that said, more research is needed on mental health challenges, including depression, experienced by women across the life span.[7]

Another category of female veterans that needs targeted outreach is the lesbian and bisexual community. Sexual and gender minority women veterans struggle with unique challenges both during active service and during transition.[7] One cohort study performed on 365 women veterans within two large VA facilities showed that for those who self-identified as lesbian or bisexual, there were higher likelihoods of having experiencing military and/or childhood sexual trauma and becoming hazardous drinkers. Statistically and practically, their mental health was in a worse state in relation to heterosexual women.[68] Additionally, younger lesbian and bisexual veterans attending college may be at increased risk for problematic mental health symptoms, which is of increasing concern given many younger veterans are using educational benefits from the Post 9/11 Veterans Educational Assistance Act of 2008.[69,70] Health care providers need to be aware of this community of veterans, and ensure they are referring them to appropriate and culturally sensitive support groups and services.[71-73]

Studying mental health can be a complicated process, as symptoms manifest on multiple levels and vary greatly from one patient to the next. In the military, understanding mental health is important from two key angles. Prevention of illness and stress disorders saves the military services money and training time, and treatment of conditions accrued during service is an ethical responsibility.[73] The Department of Defense and VA have prioritised combatting both diagnosed and undiagnosed depression specifically because it is a known predictor of suicide.[1]

Military subculture is unique and requires culturally-palatable programming, and understanding the uniquely liminal space occupied by female veterans is necessary. The challenge for health professionals looking to stem the tide of service suicides and improve quality of life for female veterans lies in shifting the paradigm away from a focus on health and mental health problems and towards theories and methods of resiliency cultivation, preparation, and self-care practices.[34]

Resilience-training methods have been demonstrated to reduce stress and emotional reactivity and promote mental health and emotional well-being; framing this as promotion of combat fitness, resilience, and mental endurance may render it culturally-palatable to the military population.[65] Receiving training to cultivate resilience in the pre-deployment interval may help protect against the deleterious effects of the high-stress military context on physical and psychological health.[36,74-75]

The results of our study suggest targeted programming is needed for female veterans in treating and preventing depression and in select sub-populations of female veterans. A need exists for further research that explores the attitudes, beliefs, and opinions of veterans toward programming that is focused on resilience-building, particularly in

veteran populations in postsecondary educational settings given the high numbers of younger veterans attending postsecondary institutions and the potential to introduce targeted interventions early in their life trajectories. The advancement of veteran mental health from a health promotion and education perspective could benefit tremendously from qualitative research, specifically case studies of successful resilience programming.[23] This should involve rigorous program evaluation of culturally-sensitive content that focuses on predictor variables of interest, designing and validating program exemplars that provide the best opportunity to make a difference in the mental health of veterans. Using information about significant predictors of depression in veterans to target programming is a needed first step.[20] Tailoring programs for relevance in order to resonate with veterans and rigorously evaluating them is the next.[26]

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Vitamin D Correlation with Testosterone Concentration in Male US Soldiers and Veterans

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Abstract

Background: Vitamin D has been positively correlated with testosterone in older men, but these hormonal relationships have not been examined in military personnel.

Purpose: The purpose of this study was to identify significant correlations between vitamin D and testosterone concentrations in male soldiers and veterans.

Material and Methods: This study examined unique cases of serum vitamin D assessments ordered at Womack Army Medical Center, Fort Bragg, NC, from January 2012 – September 2013. Inclusion criteria were male soldiers or veterans who had a testosterone assessment within 21 days of vitamin D assessment, yielding 796 subjects. General linear models were used to test the effect of vitamin D on total testosterone.

Results: Mean serum vitamin D concentrations were 29.2 ± 11.1 ng/ml, with 55.7% of subjects in the deficient or insufficient range of <30 ng/ml according to the US Army Medical Department guidelines. Mean total testosterone concentrations were 426.9 ± 178.6 ng/dl. Subjects in the lowest vitamin D quintile had significantly lower testosterone concentrations, younger age, and higher BMI than subjects in the highest quintile. When BMI, age, and time of testosterone measurement were included in the model to predict testosterone concentrations, the significance of vitamin D was eliminated.

Conclusion: These data show a high prevalence of vitamin D deficiency in male soldiers and veterans assessed in the southeast region of the United States. Since vitamin D deficiency may be related to hypothalamo-pituitary dysfunction in service members, future research should prospectively assess vitamin D status in comprehensive treatment plans for endocrine disorders

Keywords: 25-hydroxyvitamin D; androgen; endocrine hormones; human performance; military

Introduction

Previous research shows that vitamin D is positively correlated with testosterone concentration in older men.[1,2] Like testosterone, vitamin D functions as a hormone and is synthesised endogenously from cholesterol. Vitamin D is made in the skin from exposure to sunlight.[3] However, vitamin D is also consumed in the diet, with sources including oil-rich fish such as salmon, mackerel and herring; egg yolks and fortified foods such as milk. Vitamin D undergoes a series of hydroxylating reactions that alter its structure to form the biological active compound that binds vitamin D receptors to regulate gene expression for pathways essential to physical and cognitive performance.

Initially, vitamin D enzymes were thought to be exclusive to the liver and kidney but have recently been identified in other tissues as well. Notably, vitamin D metabolising enzymes and receptors have been identified in the testes, indicating that vitamin D may play a role in regulating testosterone production.[4] Emerging evidence strengthens support for the relationship between vitamin D and testosterone production by showing that 25-hydroxyvitamin D (25(OH)D) production occurs in the Leydig cells of testes, the site of testosterone production.[5]

Limited research has been published on vitamin D deficiency in active duty personnel.[6] A retrospective analysis of archived serum samples from 990 service members found that 35% of subjects had serum 25(OH)D concentrations in the deficient range of less than 20 ng/ml.[7] A study among female recruits entering basic training found that 57% of subjects had serum 25(OH)D concentrations less than 30 ng/ml at baseline and that 75% of subjects were in this range after completing 8 weeks of outdoor training.[8] These results suggest that outdoor training in tactical gear prevents adequate skin exposure, since basic combat training occurred during autumn in South Carolina.

A few studies in male military personnel have found high rates of vitamin D deficiency as well.[9,10] Furthermore, operational stress of military training has been shown to suppress testosterone concentrations in healthy men.[11] Considering the high prevalence of vitamin D deficiency and a potential role in the testes, it is hypothesised that poor vitamin D status limits testosterone synthesis in male military personnel. Therefore, the purpose of this study was to identify significant correlations between vitamin D and testosterone concentrations in male soldiers and veterans. Low testosterone concentrations have the potential to reduce muscle mass, initiate fatigue, limit performance, and have been shown to increase the risk for PTSD.[12,13] Vitamin D is commonly assessed at the time of testosterone measurement in military medicine. As a result, male service members tend to have testosterone assessments more frequently and at younger age than civilians.

Materials and Methods

This retrospective study examined 796 unique cases of serum vitamin D assessments ordered at Womack Army Medical Center, Fort Bragg, NC, between January 2012 and September 2013. Inclusion criteria were male soldiers or veterans who had a total testosterone assessment within 21 days of vitamin D assessment. Age at the time of the test was identified for all subjects, while body mass index (BMI), a ratio of weight to height-squared, was available for only 560 subjects. Race and ethnicity identifiers were too limited to be included in the analysis. This study was approved by Womack Army Medical Center Institutional Review Board.

Measurement of vitamin D and testosterone assessments were conducted through Womack Army Medical Center. Serum 25(OH)D concentrations were determined by liquid chromatography-tandem mass spectrometry (Quest Diagnostics, Chantilly, VA) with a detection limit of 4 ng/ml and a 8.3% coefficient of variation. Serum total testosterone concentrations were also determined by liquid chromatography-tandem mass spectrometry (Quest Diagnostics, Chantilly, VA) with a detection limit of 1.0 ng/dl and a 10.0% coefficient of variation. Since serum 25(OH)D has a half-life of three weeks,[3] subjects were included only if testosterone assessment was conducted within 21 days of vitamin D assessment. Therefore, no adjustment for season was warranted.

Serum vitamin D ranges for the purposes of data analysis in this study were based on the laboratory ranges used by the U.S. Army Medical Department (AMEDD) standards of care.[14] The AMEDD laboratory ranges follow guidelines from the Endocrine Society Clinical Practice Guideline,[3] that defines deficient as 25(OH)D less than 20 ng/ml, insufficient as 20-29 ng/ml, and sufficient as 30-100 ng/ml.

According to the Endocrine Society Clinical Practice Guideline,[12] low testosterone is defined as less than 300 ng/dl. However, the U.S. AMEDD standards of care[14] use an age-stratified reference range for males, with low testosterone cut-offs of 270 ng/dl for men aged 20-49 years and 212 ng/dl for men aged greater than 49 years.

Statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC). Summary statistics for categorical variables include frequencies, means, and standard deviations. Marginal relationships between age, vitamin D, and total testosterone were assessed using Pearson's correlations. Student's t-test and ANOVA were used to compare means. Quintiles for vitamin D were calculated using PROC ANOVA. Linear regression analysis using PROC regression was used to test the effect of vitamin D on total testosterone. In these models, age of soldiers was a covariate, and active duty vs. veteran was a fixed factor. Since testosterone varies with circadian rhythm, a categorical variable was created for assessments taken between 0700h and 0900h and those measured at other times of day. BMI was included as a covariate in step-wise regression. Interactions were tested and removed from the models if they were not statistically significant at a level of $P = 0.05$.

Results

Mean serum 25(OH)D concentrations for all 796 male soldiers and veterans were 29.2 ± 11.1 ng/ml (range 5-99 ng/ml). Seventeen percent of subjects tested were deficient in vitamin D, while 38.7% had insufficient status, and 44.3% had sufficient status. Overall mean total testosterone concentrations were 426.9 ± 178.6 ng/dl (range 12-972 ng/dl). According to the Endocrine Society Clinical Practice Guideline,[12] 24.1% of this sample had low testosterone. However, only 17.2% of the sample had low testosterone using the age-adjusted range in the U.S. AMEDD standards of care.[14]

Table 1 shows descriptive data by vitamin D status, from which a trend was observed toward lower testosterone in vitamin D deficient subjects but it was not significant ($P = 0.087$). When active duty personnel and veterans were compared, as expected, veterans were significantly older with higher BMI values and lower testosterone concentrations (Table 2). Distribution of testosterone concentrations according to 25(OH)D quintiles is shown in Table 3. Subjects in the lowest vitamin D quintile had

Table 1. Service Member age, BMI, and testosterone concentrations according to 25-hydroxyvitamin D status

	Deficient (<20 ng/ml) (n=135)	Insufficient (20-29 ng/ml) (n =308)	Sufficient (30-100 ng/ml) (n=353)
25(OH)D (ng/ml)	15.2 ± 3.3	25.0 ± 2.8	38.3 ± 9.6
Age (yrs)	39.8 ± 10.0	40.9 ± 9.7	41.1 ± 10.1
BMI (kg/m^2)	30.4 ± 4.2	29.8 ± 4.4	29.5 ± 3.7
Testosterone (ng/dl)	396.1 ± 162.5	435.6 ± 177.1	431.7 ± 184.1

Data are means ± standard deviation. BMI, Body Mass Index – data available for 560/796 subjects. No significant differences were observed at P < 0.05.

Table 2. Service Member age, BMI, and testosterone according military status

	Active Duty (n=684)	Veteran (n =112)	P-value
25(OH)D (ng/ml)	29.0 ± 10.3	30.7 ± 14.8	0.237
Age (yrs)	38.5 ± 7.9	54.6 ± 9.8	<0.001
BMI (kg/m^2)	29.6 ± 4.0	31.1 ± 4.6	0.003
Testosterone (ng/dl)	436.8 ± 178.2	366.1 ± 169.4	<0.001

Data are means ± standard deviation. BMI, Body Mass Index – data available for 560/796 subjects.

Table 3. Service Member age, BMI, and testosterone concentrations according to 25-hydroxyvitamin D quintiles

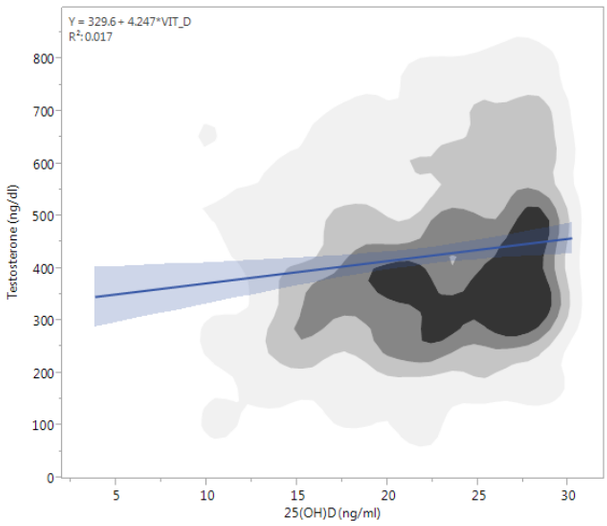
	Quintile 1 ≤21 ng/ml	Quintile 2 22-26 ng/ml	Quintile 3 27-31 ng/ml	Quintile 4 32-36 ng/ml	Quintile 5 >36 ng/ml
Testosterone (ng/dl)	398.3 ± 165.1	426.3 ± 189.6	440.3 ± 178.5*	424.4 ± 168.1	447.5 ± 189.6*
Age (yrs)	40.3 ± 9.6	40.7 ± 9.9	40.8 ± 10.0	39.6 ± 9.3	42.5 ± 10.7*+
BMI (kg/m^2)	30.6 ± 4.4	29.5 ± 4.3*	29.9 ± 4.2	29.5 ± 3.9	29.2 ± 3.6*

*Data are means ± standard deviation. BMI, Body Mass Index – data available for 560/796 subjects. Comparison between 25(OH)D quintiles were performed using PROC ANOVA. *P < 0.05 compared to quintile 1. +P < 0.05 compared to quintile 4.*

Table 4. General linear models to predict testosterone concentrations in male Soldiers and Veterans

Independent variable	Testosterone in all men (n=796)		Testosterone in men with BMI (n=560)	
	β	p	β	p
Vitamin D	1.258	0.026	0.754	0.257
Age	-3.041	<0.001	-2.615	0.001
AM Testosterone	26.120	0.037	27.870	0.066
BMI			-7.325	<0.001
Model R^2	0.039		0.065	

Figure 1. Testosterone plotted vs 25(OH)D concentrations in subjects with deficient and insufficient vitamin D. Darker areas indicate high concentration or data points. r=0.131 p=0.006



significantly lower testosterone concentrations, younger age, and higher BMI than subjects in the highest quintile. Testosterone concentration across quintiles did not show a U-shaped relationship.

Serum 25(OH)D concentrations were positively (but weakly) correlated with total testosterone concentrations in all subjects (r = 0.065; P = 0.066). However, when subjects with deficient and insufficient vitamin D status were isolated (n = 443), the Pearson's correlation was strengthened to a significant positive association (Figure 1; r = 0.131; P = 0.006).

The general linear model to predict testosterone concentrations in all subjects was significant when controlling for age and time of testosterone assessment, although the β coefficient for vitamin D was small (Table 4). When BMI was added as a covariate, the significance of vitamin D and time of testosterone measurement were eliminated.

Discussion

This study shows a high prevalence of poor vitamin D status in male military personnel and that men in the lowest vitamin D quintile had significantly lower testosterone concentrations compared with men in the highest quintile. Vitamin D concentrations showed a weak positive correlation with total testosterone although this correlation was stronger in men with deficient/insufficient vitamin D status. These results indicate that maintaining sufficient vitamin D may play a role in maintaining testosterone status. However, controlling for age, BMI, and time of testosterone measurement reduced the association of vitamin D with testosterone. To our knowledge, this is the first report linking vitamin D to testosterone in military personnel.

Previous research has identified positive associations between 25(OH)D and testosterone in male subjects, for which potential mechanisms have been hypothesised.[1,2,15] Vitamin D receptors and metabolising enzymes are expressed in the testes, most notably in testosterone-producing Leydig cells,[4] In vitro, the bone-modulating protein osteocalcin stimulates production of both 25(OH) D and testosterone in Leydig cells, indicating that bone metabolism may regulate hormonal synthesis in testes.[5] Furthermore, hypogonadism develops in vitamin D receptor knock-out mice, characterised by reduced sperm count and motility along with abnormal testicular development.[16] Vitamin D deficient rats show similar testicular abnormalities and reduced survival as well as reduced fertility and mating.[17] In human males, vitamin D deficiency is associated with hypogonadism, characterised by a combination of low testosterone and low luteinizing hormone concentrations.[15] These results suggest that vitamin D deficiency limits hypothalamo-pituitary axis function, thus altering reproductive hormone synthesis.

It is well established that military veterans with traumatic brain injury have a high prevalence of hypothalamo-pituitary axis dysfunction, including low testosterone along with additional symptoms of hypogonadism.[18,19] Therefore, poor vitamin D and testosterone status in service members may reflect more widespread endocrine dysfunction. Symptoms of vitamin D deficiency are consistent with endocrine dysfunction, such as fatigue, depression, cognitive deficiencies, and loss of neuromuscular function that may impair human performance.[18,20,21] However, no research has been published on vitamin D status in hypothalamo-pituitary dysfunction or traumatic brain injury. Since vitamin D status alters expression of nearly 300 genes related to cellular differentiation, DNA replication, and transcription, among other functions,[22] it is plausible that vitamin D deficiency inhibits androgen expression.

In our study, greater than half of male soldiers and veterans had deficient or insufficient 25(OH)D. These results are consistent with previous research showing a high prevalence of poor vitamin D status in military personnel.[7-10] In fact, mean 25(OH) D concentrations in our study were higher than concentrations measured in other male soldiers. In a study of 204 male Finnish recruits, the median 25(OH)D concentrations were 18 ng/ml.[10] while a study of male Lithuanian soldiers had a mean 25(OH) D concentration of 12.5 ± 4.5 ng/ml, with 95% of the 262 men deficient in vitamin D.[9] National Health

and Nutrition Examination Survey (NHANES) data shows that 29% of male US civilians have 25(OH) D concentrations less than 20 ng/ml and 76% are below 30 ng/ml.[23]

A potential explanation for our results is the 35.1°N latitude of Fort Bragg, in which ultraviolet rays support a longer period for endogenous vitamin D synthesis.[24] All measurements were taken at Womack Army Medical Center, although subject permanent residence and outdoor activities were unknown. However, despite the latitude, only 44.3% of subjects had sufficient 25(OH)D status in this retrospective analysis, presenting the possibility that true deficiency rates are higher if all military personnel were screened for vitamin D status. Even in a southern climate, tactical gear may interfere with endogenous vitamin D synthesis, as evidenced by our subjects having similar vitamin D status and rates of deficiency to female soldiers training at a similar latitude.[8]

Normal ranges for total testosterone vary by reference laboratory. In this study, mean concentrations were normal according to both the Endocrine Society Guidelines[12] and AMEDD Standards of Care.[14] Our mean serum testosterone was similar to the mean value of 430 ng/dl measured in 124 male soldiers (aged 28.8 ± 5 years) entering Survival Training[11] but was lower than the mean value of 684 ± 75 ng/dl measured in 23 male soldiers (aged 23.0 ± 2.8 years) entering the Ranger School.[25] With a mean age of 40.8 ± 9.9 years (38.5 ± 7.9 years for active duty only), our subjects were considerably older and their testosterone concentrations reflect the age-related decline in this hormone. NHANES data from US civilians also mirror this age-related decline, showing that men aged 20 years have mean testosterone concentrations of 393 ng/dl and these levels decline to 376 ng/dl by 50 years of age.[26]

Previous research has shown a stronger linear relationship between 25(OH)D and testosterone at low vitamin D concentrations compared to sufficient vitamin D status.[1] However, our regression models showed that 25(OH)D was not a significant predictor for testosterone after correction for age, BMI, and time of testosterone measurement. These results are similar to a European study of men aged 40-79 years, in which 25(OH)D concentrations were not significantly correlated with total testosterone following adjustment for age and additional confounders.[15] The lack of testosterone association observed in subjects with sufficient vitamin D status suggests that the relationship between vitamin D and testosterone is not linear at higher levels. Other researchers have found a U-shaped association, showing men with the lowest and highest quintiles of 25(OH)D had lower testosterone concentrations compared to men in middle quintiles.[27] On the contrary, we found men in the lowest 25(OH)D had significantly lower testosterone than men in the highest 25(OH)D quintile.

Unlike our data, a previous study found that 25(OH) D was significantly associated with total testosterone in a large sample of men after controlling for age and BM.[12] Our results support lower testosterone concentrations in older men with higher BMI, but we did not find lower 25(OH)D concentrations in older men. In fact, men in the highest 25(OH)D quintile were significantly older than subjects in the lowest quintile, and there was no significant difference between 25(OH)D concentrations in veteran and active duty service members.

We also found that BMI was highest in the lowest quintile for 25(OH)D. These findings are similar to other previous research.[1] The mean BMI in our study was 29.8 ± 4.1 kg/m2 (range 17.4 – 46.2), suggesting that most subjects were overweight, although we studied an active sample of men. Additionally, BMI data were available for only 70% of our subjects. Therefore, BMI may not accurately represent body composition in this population.

Limitations of this study include the retrospective nature of the medical record review in which we could establish correlations but not causal relationships. Furthermore, the sample was limited to subjects whose physicians ordered vitamin D and testosterone and is therefore not necessarily representative of all male service members. Lastly, data were not available for confounding variables such as race, physical activity, dietary habits, sun exposure and sex hormone binding globulin. The study was strengthened by only including assays completed within 3 weeks of one another to control for a season of vitamin D analysis, and medical records were reviewed for one geographical location to limit the effect of latitude. Future studies should consider prospective trials in service members in which vitamin D and testosterone are measured across multiple time points along with a full metabolic profile.

Conclusions

In conclusion, these data show a high prevalence of vitamin D deficiency in male soldiers and veterans assessed in the southeast region of the United States. At low 25(OH)D concentrations, a linear relationship with testosterone concentrations emerged that indicates vitamin D deficiency may limit testosterone synthesis and potentially limit human performance. However, the general linear model for all ranges

of vitamin D showed BMI and age had a stronger relationship with testosterone than vitamin D. Military personnel undergo unique physical and operational training, deployment schedules, and have greater risk of injury than civilians, thereby increasing stress to their neuroendocrine system. Since both vitamin D deficiency and hypothalamo-pituitary dysfunction plague service members, future research should prospectively assess vitamin D status in comprehensive treatment plans for endocrine disorders to optimise human performance, improve resiliency, and reduce morbidity of warriors and veterans.

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The Effects of Hippotherapy on Motor Performance in Veterans with Disabilities: A Case Report

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Abstract

The purpose of this case report was to compare traditional physical therapy to hippotherapy combined with traditional physical therapy on the motor performance of a 34-year-old male military veteran with low back and neck pain. Hippotherapy, as a treatment strategy, uses the movement of a horse to improve the subject's neuromuscular function and sensory processing through the motion of the horse in its variety of gait. Outcome measurements for this subject included the Sheehan Disability Scale, Oswestry Low Back Pain Questionnaire, and the Neck Disability Index. The combination of hippotherapy and traditional physical therapy resulted in greater improvements in disability scores on all three outcome measures compared to traditional physical therapy alone.

Key words: hippotherapy, veteran, low back pain, physical therapy, equine

Background

American Hippotherapy Association[1] (AHA) defines hippotherapy as a physical, occupational, and speech-language therapy treatment strategy that uses equine movement as part of an integrated intervention program to achieve functional outcomes. Using a horse in therapy was beneficial for many reasons.[2,3,4,5] The horse's pelvis demonstrated a three-dimensional movement pattern similar to a human's pelvis while walking,[3,4,5] which provides rhythmic and repetitive physical and sensory input to the client.[2,3,4,6] The variability of the horse's steps allows the therapist to evaluate the degree of input to the subject, and then use this movement in combination with other treatment strategies to reach desired therapy goals.[5] The horses' gait established a foundation for improving neurological function and sensory processing, which can be instrumental to a wide range of daily activities in addition to addressing functional outcomes and therapy goals.[4,7] According to Meredith S. Bazaar,[1] a licensed speech-language pathologist, board certified hippotherapy clinical specialist, sensory integration via hippotherapy, simultaneously addresses the vestibular, proprioceptive, tactile, visual, olfactory, and auditory systems. Therefore, movement of the horse helps accomplish speech, language, swallowing, cognitive, physical, and occupational goals that were established in therapy.

Rationale

Hippotherapy is useful in physical therapy. Horse based therapy facilitates balance and posture control, increased strengthening and assists in an improved range of motion.[8]

Current research demonstrates that hippotherapy is beneficial for those with developmental, skeletal, psychological, or neuromuscular conditions.[9] Examples of such disabilities include cerebral palsy, arthritis, amputation, scoliosis, Down syndrome, traumatic brain injury, and spina bifida. Most commonly the patients were children, with lower extremity spasticity due to neuromuscular disorders receiving hippotherapy (e.g., cerebral palsy, spinal cord injury).[10] Hippotherapy remained an experimental treatment for all diagnoses due to the limited quantity of published literature supporting its efficacy in individuals with disabilities.

Research Design

The researchers obtained approval for the hippotherapy study from the Arkansas State University Institutional Review Board. Participants are referred to the program either through self-referral, physician referral or through the Beck Pride Center. As not all participants present with comparable impairments, a single subject design permits reporting of outlying cases in the literature. Therefore, a single subject design examined the interactive effect of two or more treatments (control and treatment).[11] In this study, the effectiveness of hippotherapy in conjunction with traditional physical therapy, the experimental treatment, was compared with the control treatment of traditional physical

therapy in an individual patient. Several data points were collected after each treatment session to allow more accurate measurement of overall functional improvement. Sufficient data points permitted a publishable report based on the subject's unique disability.

The risks associated with this study included but were not limited to falls, muscle injuries, and fractures. Therefore, subjects included must be 18 years of age or older and have a physician determined need for physical therapy. Individuals with severe horse allergies, unstable fractures, atlanto-axial instability (excessive movement at the junction between the first two cervical vertebrae), or the inability to balance in a seated position could not participate in the study.

After a licensed physical therapist determined that the subject was eligible for participation and obtained informed consent, the subject was randomly assigned to Treatment A via a coin flip. In this first treatment group, he received both hippotherapy and traditional physical therapy, each for one hour once per week. After 15 weeks in Treatment A, the subject moved to Treatment B, receiving traditional physical therapy twice a week for one hour. The study lasted for 30 weeks, and the same physical therapist oversaw the duration of the patient's care in both groups. Three main outcome measures were collected after individual treatment sessions: the Sheehan Disability Scale (SDS; Sensitivity 0.83, Specificity 0.6912), the Oswestry Low Back Pain Questionnaire (OLBPQ; Sensitivity 0.76, Specificity 0.6313), and the Neck Disability Index (NDI; Sensitivity 0.74, Specificity 0.6614).

Case Presentation

The subject was originally referred to the study through the Beck Pride Center. He was a 34 year old male with a history of low back pain, neck pain, and a moderate stutter secondary to post-traumatic stress disorder (PTSD). He has lived with all of his impairments since he was discharged from the service.

Intervention during a one hour hippotherapy session involved retrieving the horse from the pasture or stall; tacking the horse (putting on appropriate gear to ride, i.e. saddle, etc.); brushing and grooming the horse; mounting the horse via the use of the mounting ramps; riding the horse facing forward, backwards, and sideways; performing strengthening and stretching exercises; changing directions and speeds while on the horse; dismounting the horse via the mounting ramps; untacking the horse and returning the horse to the pasture or stall. Every session was performed by a licensed physical therapist, certified in hippotherapy as recognised by the AHA, along with a trained horse handler, and two trained side walkers. At the end of each session a licensed physical therapist evaluated the patient, and the patient completed a questionnaire evaluating improvement.

A traditional physical therapy session lasted approximately one hour and was the same during both experimental and control phases of the program. Intervention for the subject included stretching and strengthening exercises, manual therapy, educational training, and physical agents such as hot packs, cold packs, ultrasound, and electrical stimulation. At the end of each session, the subject was evaluated by a licensed physical therapist and then filled out a questionnaire evaluating improvement.

Measurements of motor performance were taken following each session. Evaluations included a range of motion, strength, balance, gait analysis, and posture. The results were analysed and compared to see if they are similar or different.

Tools used to measure changes as a result of treatment included a NeuroCom Balance Master, Gait Rite, Parotec Gait System, Lite Gait, Biodex, and functional scales. Other equipment utilised in treatments included an equine approved helmet, tack equipment- saddle, bridle, brushes, etc., gait belts, mounting ramps, Life System, and therapeutic exercise.

Examination Findings- Data and Analysis

The results of the three main outcome measures (SDS, OLBPQ, & NDI) were graphed and visual analysis was used to evaluate the graphs of the single subject data. Visual analysis was selected because, with basic information, outcomes can be accurately predicted using this method.[11] Data trends for all three measures showed the subject's marked improvement with the addition of hippotherapy to his treatment program. The subject reported decreased low back and neck pain following hippotherapy sessions. In addition, as therapy progressed the subject's stutter, present at initial evaluation, became less frequent and eventually disappeared.

While all three measures showed numerical improvement, only the Sheehan Disability Scale reached statistical significance according to visual analysis (Figures 1 & 2). The Oswestry Low Back Pain Questionnaire and Neck Disability Index both demonstrated clinical significance by improving function more than the minimal clinically important difference (MCID, Oswestry=1515, NDI=9.514) and both scores decreased over 50%. The figures below represent the data collected from the Sheehan

Disability Scale in the experimental and control phases of treatment. The dates of treatment are located on the x-axis and the results of the day's measures are plotted on the y-axis. The rate of improvement is the slope. By looking at the slope, a trend, or direction of change, can be seen in the data.

Figure 1. Hippotherapy Plus Traditional Physical Therapy, measure of disability and impairment. Data measured using the Sheehan Disability Scale.

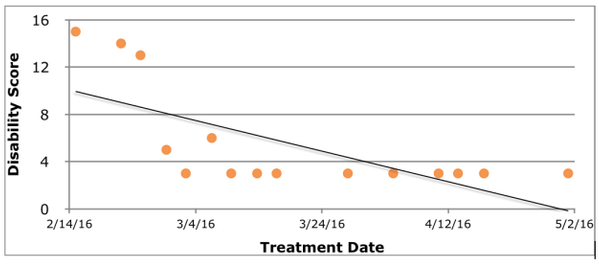
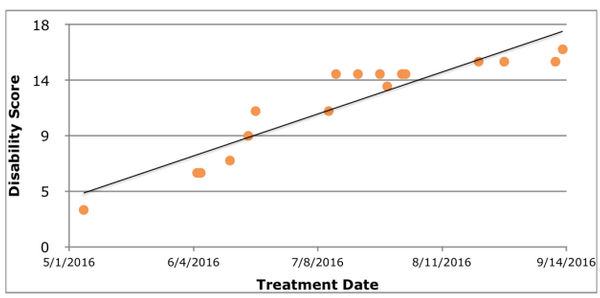


Figure 2. Traditional Physical Therapy only, measure of disability and impairment. Data measured using the Sheehan Disability Scale.



Discussion

The subject showed a greater response to hippotherapy combined with traditional therapy than to traditional therapy alone. While he was a compliant patient, he became disappointed when the horse was withdrawn and required strong encouragement to complete the data in the Treatment B of the program. The traditional physical therapy treatments were comparable during both experimental and control sessions. After completion of the control data, the subject eagerly returned to hippotherapy treatment. Thus, while hippotherapy produced effects that could be sustained over time, in this case the decreased motivation and eagerness of participation and other external factors may have played a role in increasing disability levels during the control portion of the program.[4,5,16] Among other factors, the subject was a university student whose course load varied between the two semesters and who experienced external stressors during the last half of the program due to family dynamics. His enthusiasm for horse-based therapy suggests that he would have responded well to hippotherapy alone, but he also demonstrated more willing participation in traditional therapy when combined with hippotherapy.

While single-case design studies provide rich data, several limitations should be noted. The small sample size did not allow the results to be applied as freely to larger populations. The Hippotherapy Program treated a wide variety of diagnoses, which also limited the ability to aggregate data and generalise conclusions. Power was limited in the statistical data secondary to single case design. Despite the low power, both statistically significant and clinically relevant improvements were demonstrated in an individual case. Determining confounding factors is difficult in this study. Exclusion bias exists as there are several exclusion criteria due to using the equine center. Selection bias exists as subjects are primarily referred from the Beck Pride Center.

The Beck Pride Center was established in 2007 at Arkansas State University. Services offered by the center were designed to fill gaps in an underserved area and supplement, not duplicate, existing government benefits while providing support for United States Veterans returning from service and entering higher education. Examples of services provided at little or no cost include physical rehabilitation, mental health counselling, advocacy, benefit assistance, and career or vocational development.

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Conclusion

The subject reported decreased disability with low back pain, decreased neck pain, and disappearance of stuttering following hippotherapy sessions. This evidence suggests that hippotherapy may result in physical benefits for some veterans. Hippotherapy has the potential to restore, maintain, and promote

physical function as well as quality of life in aspects of disability, in some individuals. Further research is indicated.

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Joint Expeditionary Medical Support in 1914: The US Occupation of Veracruz, Mexico

Sanders Marble

Keywords: Military Medicine/history; Military Medicine/organisation & administration; Preventive Medicine/history

On Tuesday, 21 April 1914 US sailors and Marines landed at Veracruz, Mexico. There were two days of sporadic fighting by the 'Bluejackets' and Marines followed by almost seven months of occupation by Army and Marine forces. The two services would draw limited lessons from the joint occupation, and thus of joint expeditionary medical support.

Background

On 19 February 1913 Gen. Victorianio Huerta overthrew the Mexican government and installed himself as president.[1-3] US President Woodrow Wilson (inaugurated 4 March 1913) was shocked by the assassinations and determined "I am going to teach the South American republics to elect good men." In support of that policy, and as competition among Mexican factions turned into civil war, he would escalate the use of force. A series of actions by the Mexican government, and accidents by local Mexican troops, were interpreted as escalating provocations, and by April 1914 much of the Atlantic Fleet was off the Mexican coast not just to influence Mexican politics but for potential evacuation of American citizens. The flashpoint seemed to be Tampico, where a US Navy boat crew was detained when they approached the frontline between Mexican government and rebel forces. However, news of a shipment of machine guns and ammunition to Veracruz shifted US focus there; occupying Mexico's main port would also block any efforts by Huerta to raise a loan secured by customs duties.

Combat and Casualty Care

The landings began at 11.00h, with 285 Bluejackets (sailors, executing their infantry training) from the USS Florida and 502 Marines, some from ships' detachments and some from the 2nd Advance Base Regiment aboard a transport; the plan was only to occupy port facilities and not the entire city.[2] The Mexican commander wanted no real resistance, and withdrew his roughly 1,000 regular infantry. However, a few chose to remain and he had armed over 300 paramilitaries of the 'Society of the Defenders of the Port of Veracruz' and also some 'stripers' (prisoners released from the jails and wearing their striped jail uniforms); an unknown number of civilians also took up arms against invading *gringos*.[2] There was little organised fighting but much sniping; US casualties on the 21st were 4 dead and 20 wounded.[2] (Mexican casualties were never certain since many never went through hospitals but were over 200 dead and 300 wounded and may have been double that).[2] As improvised units, the ad hoc Bluejacket regiments and the Marines from the ships' detachments had no formal medical support, but a doctor and some medical personnel from each ship went ashore. Aid stations were established in the Hotel Terminal and at the main pier with a total of six doctors.[4] Naval medical personnel, officers and enlisted, were forward with the fighting men. HA1 William Zuiderveld dashed through a hail of gunfire to reach a wounded sailor; alone, and ignoring the fighting around him, Zuiderveld bandaged his comrade's head and hauled him back to further aid, although ultimately to no avail.[5] When firing broke out surgeon Middleton Stuart Elliott, Jr, left the aid station at the pier "ran to the firing line and helped to carry some of the wounded being brought out to the battle aid station."[5] Elliott's small aid station, hardly safer than the front line, would ultimately treat 63 wounded Americans. The hospital ship USS *Solace* was off Tampico and the number of wounded taxed the medical personnel on the transport USS *Prairie*; British and Spanish naval surgeons (from their warships offshore to protect their nationals) came aboard and helped treat the wounded.[3] Admiral Fletcher, the US commander, reported "Their assistance was gratefully accepted."[3] The resistance showed more American forces were needed, and most of the ships at Tampico were ordered south on the 21st, arriving before dawn on the 22nd.

Image 1: US troops enter Veracruz, April 1914. Image courtesy Library of Congress.

Image 2: Putting patients from the Solace in a horse-drawn ambulance, New York City, May 1914. Image courtesy Library of Congress.

More Bluejackets and Marines came ashore, 6,000 by dark on the 22nd; the 3,000 Marines were roughly one-third of the Corps. The only major firefight developed after Bluejackets marched towards the Mexican Naval Academy not realising it was unsecured; a burst of fire hit many Americans and surgeon Cary Langhorne "unhesitatingly ran toward the wounded and retrieved a severely injured man from the attack."[5] After that fighting, it was clear the rest of the city had to be occupied, and the extra men could go house-by-house and also push out beyond the city to secure the water-treatment plant. The Marines took periodic casualties (13 killed and 41 wounded) in the house-clearing and the corpsmen with them also went forward under fire.[3,4] Fighting an unidentifiable enemy was frustrating and the Atlantic Fleet commander commented "I rather think that as increasing numbers of our men were killed or wounded, that eventually it fared rather badly with those discovered with arms in hand on the spot from which shooting came".[2]

At mid-day on the 22d the *Solace* arrived and received the American (and a few civilian) wounded.[3] While the *Solace* had an X-ray machine, most care was conservative, keeping with surgical priorities of the time.[6,7] Debridement was not normal ("greatly devitalised tissue" was allowed to slough off "and healing went on by granulation"), and abdominal surgery was considered more dangerous than observation in an era before sulfas, let alone antibiotics. While *Solace's* doctors promptly performed a trephination, for at least two patients they waited several days to observe compound fractures and ended up with above-knee amputations due to infection. In early May, the *Solace* unloaded its civilian patients and returned to New York; it was an older ship and needed repairs. Instead, a Navy field hospital opened ashore to support the Marines; it operated alongside an Army field hospital.

On 23 April an Army brigade at Galveston, Texas, had been warned for service in Mexico; embarked on the 24th, by the evening of 27 April it was afloat off Veracruz. It stayed afloat until 29 April until questions of command were resolved: would the Marines stay ashore and if so, who would be in command? The Cabinet met and President Wilson decided the Marines would stay and be under Army command. The next day the Army brigade landed, the sailors rejoined their ships, and Brigadier General Frederick Funston found himself in charge of Veracruz – in charge of all aspects of government, since Mexican law had stringent punishments for any public official who helped an invader. (Individuals could work for an invader, for instance as teamsters, but not as officials.) The US would stay in Veracruz an unknown amount of time to influence the Mexican civil war, but Funston received orders not to advance and avoid fighting if possible. (Lieutenant Douglas MacArthur would see his first action in early May, scouting for railway locomotives and having a daredevil return trip to Veracruz with four bullet holes in his clothes after shooting at least six Mexicans.)

Occupation and Public Health

Veracruz was a filthy city, with no municipal trash service except stray dogs and vultures; there was a 5-peso fine for harming a vulture.[2, 8-10] Chickens lived in the hotel kitchens, and the open-air food market had no fly screening, no working drains, and no inspections. Unsurprisingly, the civilian death rate was 50/1000/year.[2] Tuberculosis was common, and the military doctors took care selecting buildings to quarter troops. With the hot season coming soon, bringing malaria and potentially yellow fever, quick sanitary work was needed. The Army established a medical structure: COL Henry Birmingham was double-hatted as Chief Surgeon of the Expeditionary

Force and Chief Sanitary Officer for the Military Government. (Birmingham had had several years' experience of managing healthcare for troops mobilsed in Texas, the closest analog the Army had to Veracruz in climate and number of troops.) Each military service had a hospital, the Army had the 216-bed Field Hospital No.3 in the most appropriate building in the city, the Marines an improvised hospital in a small schoolhouse when *Solace* was not on station. The Public Health Service was brought in to continue maritime quarantine; Army doctors were detailed for public health work but assigned to the Department of Public Works since that was where the labour force was. Field Hospital No.3 (normally an extremely austere organisation mainly for 3-day holding) was augmented with a laboratory, an X-ray machine, beds rather than sacks for straw, and various other low-mobility items. A proper operating room was established, and a dental clinic. The Army sent 12 nurses, their first operational deployment close to a potential frontline, but there are no details on their duties other than general hospital nursing. A special field uniform had to be devised, blue-grey material with white collars, cuffs, aprons, and caps. Given the possibility of fighting, a horse-drawn provisional ambulance company was organised, and field equipment retained when garrison equipment arrived. A small medical supply team (one doctor and five enlisted men) deployed, and ultimately supplied both Army and Navy medical facilities.

For the military force, malaria prophylaxis was enforced; 3 grains of quinine sulfate/man/day and 6 grains for those quartered near the most malarious districts. Fly screens were installed in military quarters, toilets, kitchens, and messes. Manure and garbage were hauled to the city dump for incineration. Troops drank city water, but it was regularly checked; a chlorination system was installed in case but was never necessary.[9] Troops were ordered to shower regularly to reduce the incidence of skin diseases. Local vegetables had to be cooked, and canned goods and meat hashes to thrown away if they went unrefrigerated overnight. Surgeons were to make sure there were no mosquito-breeding areas around barracks. Various medical indicia (e.g. fever of 101°° with albuminuria) were listed as friendly forces information requirements.

Sanitary work was urgent, and done urgently: in early May half the Expeditionary Force and thousands of Mexicans were sweeping the streets, burning trash and garbage, draining water, installing bug screens, and performing other preventive medicine tasks. (Ashes from the burned trash, plus clinker from the coal-fired naval vessels, became filler for potholes and swampy areas and an all-weather road to the dump.) Malaria patients were hospitalised, then sent home with two months of quinine to prevent relapses and the spreading of infection. 1,000 garbage cans were provided city-wide with the city emptying them thrice daily and hauling waste to the dump rather than requiring citizens to do it themselves; compliance rose, and the cans themselves were cleaned regularly.

Image 3: US troops burning trash. Image courtesy Getty Research Institute, Los Angeles (2001.M.20).

To reduce the disease threat the military forces faced, the Army took strong public health steps. Veracruz was in the throes of a smallpox epidemic when the Americans landed; teams went house-to-house and performed over 46,000 vaccinations. In 1906 by a vigorous Mexican official had started anti-mosquito ditches but they were subsequently neglected. The Army cleaned and repaired existing ditches, while 61 miles of new ditches were dug and house-by-house inspections were performed to look for standing water as the US revitalised and extended the work.[11] Sixty-nine thousand gallons of oil were sprayed on standing water. The food market was cleaned, with cracked flooring replaced and screens (augmented with flypaper) issued; the building was hosed out with seawater daily. Vendors who ignored sanitary regulations were warned, then fined, and ultimately imprisoned. For TB control, an ordnance banned spitting, but it could never be as thoroughly enforced. Sanitary inspectors fanned out across the city, dusting off existing laws. Thus, for instance, sanitation plans were required to obtain building permits. A Navy doctor was assigned for general oversight of city hospitals, later an Army reserve doctor who lived in Mexico and was fluent in Spanish. US government civilian sanitation experts from the Panama Canal Zone (which would open during the occupation of Veracruz) arrived to supervise various steps within their recent expertise. Given the Mexican law against collaboration by government employees, US officials ordered some of

them to perform their duties, which may or may not have protected them from reprisal.

Money found in the city coffers was spent on public health, and money was borrowed against accounts of the State of Veracruz Llave, but the US Congress also appropriated $40,000 for the work.[12] For the long term, public hospitals were cleaned and repaired, and tentative plans were made to open a hospital-based nursing school (as was then the standard in the US) if the occupation lasted longer. The city became sufficiently clean that the vultures left.

Venereal disease was a huge problem. Veracruz was Mexico's main port and half the businesses were cantinas or brothels, or both.[2] The Army controlled the Board of Health, the Police Department, and the Women's Hospital and could make some headway. The government tried to channel prostitution to the legal 'red light' district for better enforcement of laws about bi-weekly inspection of prostitutes. Inspections found 25% of registered prostitutes infected against 90% of "clandestinas." Infected prostitutes were treated at a "lock" hospital, with up to 125 patients at one time. The Army also inspected the premises and forced unsanitary ones to clean up or close.[2] Prophylactics, with instructions in Spanish and English, were made freely available at "registered resorts." The Army expelled foreign-born prostitutes from the city effective 1 July, although some obtained pro-forma marriages with Mexican men. Salvarsan (arsphenamine) was available to treat US personnel, and the field laboratory at the Army hospital performed all STD tests, military and civilian. (The Army used its medical laboratory not only for military government work, for instance confirmation of malaria cases and inspection of prostitutes, but also made it available to local physicians for their patients.) US officers were forbidden to enter brothels or even visit the red-light district in uniform.[3] These measures did not stop STDs; the annual infection rate for US personnel was 359.70/1000/year.

NGOs

From 23 April to 2 September the American Red Cross (ARC) conducted relief work in Veracruz; Admiral Fletcher (commander of the blockading squadron) asked for an experienced relief agent on 29 April.[13] It limited its work to ameliorating the "suffering due either directly or indirectly to the American occupation." This included helping released political prisoners and families of Mexican soldiers but also those who the US occupation put out of business, such as lottery ticket vendors when Funston banned that amusement. Food, money, or medical care was provided, when need was verified. Transportation

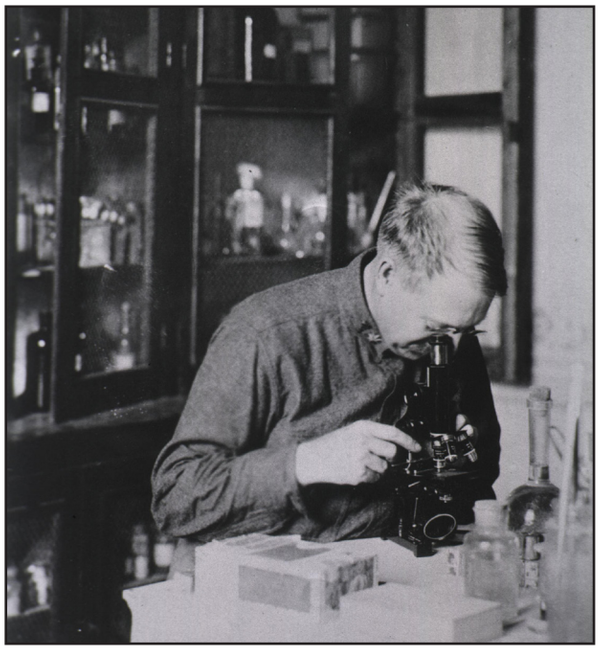

Image 4: Laboratory of Field Hospital No.3, with MAJ Frederick Russell, developer of the typhoid vaccine, at work. Courtesy National Library of Medicine.

was provided both for foreign refugees who needed to return home and getting Mexicans out of Veracruz when they could persuade the ARC that they would be able to support themselves elsewhere. (This could include returning them to their families.) A clinic treated around 6,000 patients. The ARC helped people find work, including labour for the military government. The ARC also helped American refugees leave other ports on the Gulf Coast, where American warships could have inflamed the situation. The ARC provided public health nursing services to the occupation government for an anti-tuberculosis campaign; Mexican civilian nurses were hired to visit homes, presumably getting a better response than US military personnel or Army Nurse Corps (Female) personnel. The Army asked the ARC to run a TB hospital, but the ARC could not secure adequate funds. The Mexican Neutral White Cross, established because the Mexican Red Cross was under government control and would not treat anyone who opposed the government, also operated a medical facility, but no details are available.

Health Outcomes

There were no significant differences between Navy Department and War Department health data, nor between Veracruz and garrisons in the US.[14] Malaria and the venereal diseases were the largest problems, followed by diarrhoea and enteritis.[15] Sanitation worked: there was a higher incidence of

"alcoholism and its results" (29.56/1000/year) than of dysentery (23.31/1000/year). The admission rate was 945/1000/year, with 862/1000 being disease and 83 injury. However, acuity was low with days hospitalised 7.32/soldier and a daily census of 20 – one quarter of whom were VD patients. Deaths (after the fighting) were only 14, seven disease and seven injuries. The death rate for the local population fell from 45.59/1000 (January-May) to 30.59 (June-October). Malaria deaths were only 2/month, even in the summer heat.[9,12] But there was negligible long-term impact: by June 1915 "the streets were filthy, with garbage very much in evidence, decaying on the streets and attracting myriads of flies and other insects" and there was another smallpox outbreak, presumably among refugees.[16] The vultures literally returned.

Image 5: Vultures at the meat market, Veracruz. Image courtesy DeGolyer Library, Southern Methodist University.

Lessons

The occupation ended in November 1914. Huerta had actually fallen in July, but negotiating how the US would withdraw took time. The doctors hoped the sanitation measures would survive, and both line and medical officers hoped that the Mexicans who had worked with them would not be persecuted by the new regime. The War Department pressed the State Department and President Wilson to negotiate guarantees for those individuals, but ultimately Wilson accepted the pledge of *Presidente* Venustiano Carranza, who was unable to exercise his will in Veracruz.

There were some mild administrative problems with a joint occupation, but nothing more than extra paperwork.[14,17] For instance, when the Army provided the Navy medical supplies extra receipts were necessary since a Navy appropriation had to be debited and an Army one credited. Navy Department patients required Navy and Army forms to be completed; the Marines' Navy doctor reported to both the USMC commander on the ground and COL Birmingham as force surgeon. The Army could not pay for Navy hospital laundry. These lessons were minor. Similarly, the Army learned that the standard monthly health report was not sufficiently frequent and adopted weekly reports.[18]

The services learned that standardised supplies and equipment made field operations easier. The Marines learned they needed battalion and regimental support structures that could support split-base operations.[19] The *Solace's* problems showed the need for newer, ideally purpose-built, hospital ships.[4,19] The Army learned a passive lesson, that in static situations medical units will accrete extra equipment to raise the standard of care. However, the Army had much experience of medical support in tropical environments (Cuba 1898 and 1906, Philippine Islands and Puerto Rico 1898-onwards, Panama 1905-onwards) and the Veracruz experience taught little except to reiterate how hard it was to make cultural changes. The Army would soon have more field experience chasing Pancho Villa in Mexico,[20] and the two services would have more joint experience in World War I, when the 2d Infantry Division had one Army and one Marine infantry brigade.[21]

Birmingham was effective in his dual roles as chief surgeon and chief sanitary officer. To bring about medical changes, the medical adviser had to be credible with his commander. Funston listened to Birmingham, and Birmingham worked through the non-medical Department of Public Works and the Police Department. Birmingham also handled the joint situation with tact; he did not try to micromanage medical support to the Marines, and he handled the presence (or absence) of the *Solace* without problems. He used the American Red Cross (and apparently the Mexican Neutral White Cross) as effective force multipliers. We should remember Zuiderveld, Elliott, and Langhorne for their courage in treating their comrades under fire (for which they received Medals of Honor), and we should remember the other purpose of military medical departments, of providing a commander with a medically-ready force. Birmingham did that, and managed to do so for an ad hoc mission which changed from a brief intervention to an open-ended occupation.

In the larger picture, the doctors at Veracruz certainly kept their force healthy, but they had no lasting impact on the community. They only sought to make the city medically safe for their own forces, and did not try to

change local ways. Enforcing local laws, rather than dictating new ones, was culturally sensitive, but the necessity for the laws had not percolated from the Mexican governing elites to the populace. There was no formal doctrine on using medicine as 'soft power' to win support, and, moreover, the entire operation was aimed at Mexico's political elites and not the populace so there was no intent to win grassroots support. Yet medical officers of the period understood that public health was a way to win support. The US had organised a health department in Cuba in 1900, and had used well-drilling and sanitation as ways to improve living conditions for Filipino villagers to reduce opposition there. They also had experience with local populations not adapting to 'advanced' ways: Cuba did not maintain its sanitation efforts after US withdrawal, and the second US occupation (1906-09) had to make further changes in Cuban law, including taxation, to embed the changes.[22] Then, as now, it is harder to make a systemic difference, as shown by uneven results from repeated efforts in Afghanistan and Iraq.

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A Systematic Review of the Impacts of Active Military Service on Sexual and Reproductive Health Outcomes Among Servicewomen and Female Veterans of Armed Forces

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Background

There are clear evidence gaps relating to health outcomes of servicewomen and female military veterans (here included as servicewomen). In addition to physical health, mental wellbeing and maternal health, there is limited literature regarding their sexual and reproductive health, particularly within an international context.[1] Internationally, a recent increased focus on the health of servicewomen and female veterans reflects both increased numbers of females in the military and removal of duty restrictions. Consequently, specific policies addressing pregnancy, breastfeeding and return to work have been developed, although research evidence to inform these is lacking. Identifying available evidence and mapping evidence gaps is critical to develop policies that will support the future female military workforce. Therefore, as a basis to address these emerging issues, an evidence mapping review was conducted to identify reproductive and sexual health issues faced by servicewomen, and establish the evidence gaps and target areas for future research.

Method

A systematic literature search of library databases was undertaken in April 2015, including Embase, Medline, PubMed, Web of Science, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Cochrane Database. The following Medical Subject Heading (MeSH) terms were searched in title, abstract and keyword fields: servicewomen; veterans; military; Defence; reproductive health; menstruation disturbances; menopause; premature; fertility; contraception; contraception behaviour; pregnancy; female urogenital diseases; pregnancy complications; obstetric surgical procedures; hydatidiform and mole. To broaden the search, the reference lists of all included studies were examined to identify any other potentially relevant papers (Pearling). Results were limited to studies published in English, from the year 2000 to the present.

Exclusion criteria from the initial search included:

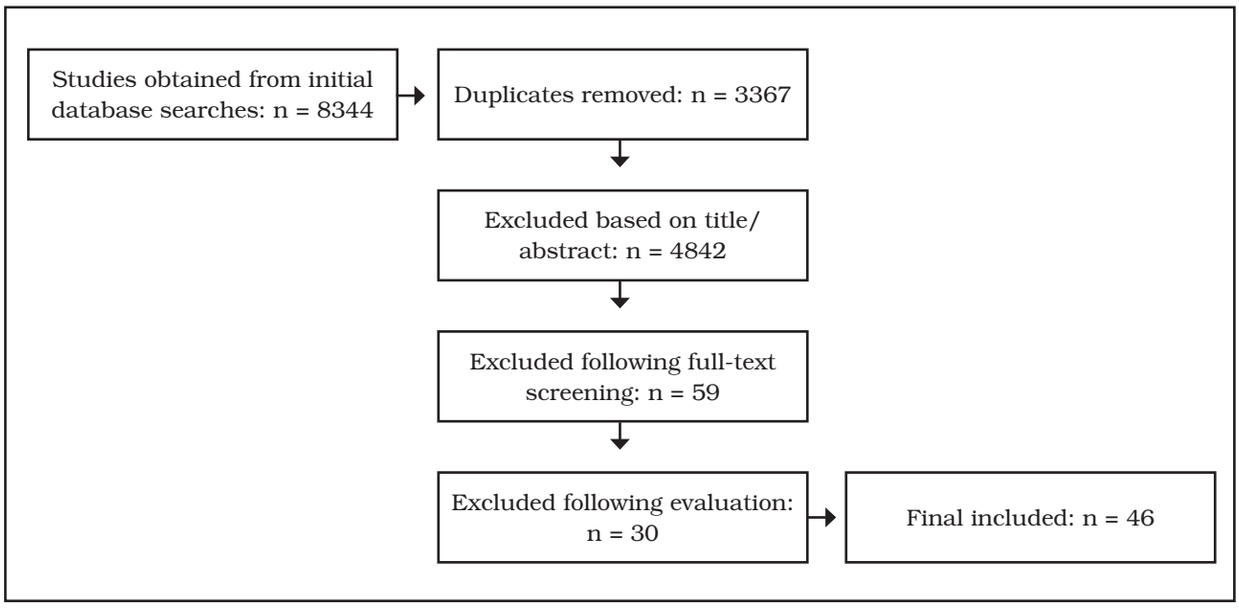
- Not published in English,
- Published prior to 2000,
- Not published in peer-reviewed journals,
- Editorials or correspondence,
- Did not involve servicewomen or female veterans,
- Did not report reproductive or sexual health issues.

Included studies were assessed on their level of evidence according to the Australian National Health and Medical Research Council (NHMRC) hierarchy of evidence,[2] and data regarding country of origin, study aim(s), population, sample size and key findings (Table 1), were initially extracted from ninety-six relevant studies. Inclusion criteria were further refined to focus on:

- Servicewomen and female veterans of the military forces (active service)
- Sexual and reproductive health impacts, effects of and associations with military service

Where possible a non-service comparison group was preferred, however broader criteria were utilised to provide the most comprehensive overview of available published research. Due to the limited research

Figure 1



in this area, studies of lower evidence addressing issues of interest were retained, though findings were interpreted with caution. A total of 76 papers were independently evaluated by the lead author and another reviewer, with 46 included in this review (see Figure 1).

Results

The majority of published research in this area comes from the United States (US), which has the largest cohort of females in active military service. Initial assessment identified the following key areas where impacts of active military service could be examined: (1) general reproductive and sexual health; (2) menstrual regulation and menopause; (3) birth control; (4) pregnancy incidence and birth outcomes; and (5) post-pregnancy health and wellbeing. Papers were grouped accordingly, with active service and deployment-specific findings examined separately where appropriate. An assessment of the available evidence is summarised for each outcome, and conclusions regarding the state of evidence in the area as a whole is presented, including an overview of notable gaps. Key study information and findings, organised by topic, are summarised in Table 1.

General reproductive and sexual health

There were only a small number of studies that addressed general reproductive and sexual health. This included two reviews, one small qualitative study, and two large administrative database studies. Evidence from these suggests higher healthcare use by females compared to males, of which a substantial proportion relates to gynaecological, contraceptive and menstrual issues. Sexual assault, unintended pregnancy on deployment, pregnancy termination, and infertility among female veterans were also highlighted. However, in most studies there was insufficient evidence to determine whether these issues are specific to military service.

A small qualitative study from Doherty and Scannell-Desch[3] indicated gynaecological infections, suppression of menstruation, unintended pregnancy and other experiences (e.g., difficulties accessing bathroom and toilet facilities, hygiene and cleanliness issues, personal safety) as important issues in the deployed environment. While this study was limited in terms of size and scope, the findings are consistent with those from earlier work in this area.[4] These types of gynaecological issues may also persist post-deployment.[5] Menstrual disorders and endometriosis were the most frequent reproductive health diagnoses among US servicewomen aged 18–44 years.[6,7] Additionally, Katon et al.[6] reported a higher prevalence of mental health diagnoses among women with these conditions, possibly reflecting a greater need for attention.

Recent studies demonstrate an emerging problem of sexual assault in the military with 11-48% of female veterans reporting sexual trauma during their service.[2,8,9] Military sexual trauma can lead to deleterious physical and psychological comorbidities, including termination of pregnancy, delayed or avoidance of pregnancy as well as infertility, sexually transmitted infection, posttraumatic stress disorder and postpartum dysphoria.[10,11]

Table 1. Summary of papers included in review, organised by key topics.

General reproductive and sexual health							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Doherty & Scannell-Desch (2012)	USA	Qualitative interviews	Qualitative	NA	Women deployed to MEAO	24	Themes identified: Bathroom and toilet facilities Shower challenges Menstrual suppression/ regulation Hygiene Genitourinary infections Unintended pregnancy Personal safety
Haskell et al. (2011)	USA	Observational study of VA administrative and clinical databases	Retrospect-ive cohort	III_2	Veterans 1yr post-deployment MEAO	19520 female	Among female veterans: 13% had a gynaecologic examination 7% sought assistance for menstrual disorders 10% sought contraceptive counselling
Katon et al. (2015)	USA	Cross-sectional analysis of VA administrative and clinical data	Cross-sectional	III_2	Women Veterans using VA health care in FY10.	Women aged 18–44 (n = 12492), 45–64 (n = 3437), Age ≥65 (n = 38963)	Most frequent reproductive health diagnoses were: Menstrual disorders and endometriosis among those aged 18–44 (n=16658, 13%) Menopausal disorders among those aged 45–64 (n = 20707, 15%), Osteoporosis among those aged Z 65 years (n = 8365, 22%). Compared with women without reproductive health diagnoses, those with such diagnoses were more likely to have concomitant mental health (46% vs. 37%, P < 0.001) and medical conditions (75% vs. 63%, P < 0.001)

Rossiter and Smith. (2013)	USA	NA	Case study/ review of literature	NA	Service women		~26,000 women have experienced some form of sexual assault in the military Military Sexual Trauma (MST) can lead to multiple physical and psychological comorbidities including pregnancy issues, infertility, sexually transmitted infections, PTSD and postpartum dysphoria It is imperative that nurse practitioners ask women about military service and utilize the Military Health History Pocket Card for clinicians to ascertain service-connected health risks, primarily MST and PTSD Prompt identification and intervention is key to reducing physical and psychological comorbidities
Ryan et al. (2014)	USA	Computer-assisted telephone interview	Cross-sectional observational study	IV	Female veterans (aged 20–52 years) enrolled at two Midwestern VA medical centers or their outlying clinics (July 2005-August 2008)	1004	62% reported at least one attempted or completed Lifetime Sexual Assault (LSA) Veterans with LSA more often self-reported history of pregnancy termination (31% vs. 19%), infertility (23% vs. 12%), STI (42% vs. 27%), PTSD (32% vs. 10%), and postpartum dysphoria (62% vs. 44%) LSA independently associated with termination and infertility in multivariate models; STI, PTSD, and postpartum dysphoria were not LSA by period of life: 41% in childhood, 15% in adulthood before military, 33% in military, 13% after military Among the 511 who experienced a completed LSA, 23% reported delaying or foregoing pregnancy owing to assault

Zephyrin et al. (2014)	USA	Report	Report based on program evaluation analysis conducted by Women's Health Services	NA	Women veteran	297,392 Age18-44 n= 124092 Age 45-64 n= 134337 Age ≥65 n= 38963	43% of women Veterans who used VA in fiscal year 2010 had at least one diagnosis of any Reproductive Health condition. Top 5 diagnoses aged 18-44:menstrual disorders and endometriosis, STI and vaginitis, urinary conditions, pregnancy-related conditions Top 5 diagnoses aged 45-64 Menopausal disorders , urinary condition, Top 5 diagnoses age ≥65: Osteoporosis, urinary conditions, menopausal disorders, breast cancer, benign breast conditions
Menstrual regulation							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Christopher & Miller (2007)	USA	NA	Narrative review	NA	Military	NA	Unintended pregnancy can interfere with ability to deploy Menstruation can negatively impact female deployment experience Hormonal medications can be used to suppress menstruation Hormonal medications for menstrual suppression should be routinely available during training/ deployment
Deuster et al. (2011)	USA	Self-report questionnaires	Cross-sectional	IV	Women aged 18-45, 30 days or less post-deployment	459	Menstrual concern lower among African Americans compared to other ethnicities, with highest concern among Hispanic and Asian women Less than 50% of women took oral contraceptives, and less than 50% of them took OCPs continuously despite menstrual burden
Enewold et al. (2010)	USA	Demographic and clinical data from existing databases	Retrospect-ive cohort	III_2	Military Females aged 18-39	83181 military, 360 general	OCP use: Significantly higher in military (35%) compared to general population (29%) This difference increased with age This difference was greater for Hispanic women (military 32.2% vs general 19.8%) Use was highest in the Air Force (39%) and lowest in the Army (30%)

Grindlay & Grossman (2013a)	USA	Online self-report survey	Cross-sectional cohort	IV	Servicewomen	281	Birth control used by 63% during their last deployment 59% did not consult healthcare provider regarding contraceptives before last deployment One third of women unable to access preferred contraception method Intrauterine devices or sterilisation either not available or discouraged 41% reported difficulty accessing prescription refills
Holt et al. (2011)	USA and International	NA	Narrative review	NA	Female servicewomen	NA	Pregnancy and unintended pregnancy rates higher among servicewomen compared to general population Use of contraceptives decreases during deployment Interest in menstrual suppression using OCPs greater than actual use
Powell-Dunford et al. (2009)	USA	Self-report survey	Cross-sectional	IV	Deployed women using OCPs	56	93% were aware that continuous OCP use could suppress menstruation 81% had used OCPs During deployment: 33% used OCPs 15% of these used OCPs continuously Those who used OCPs continuously reported less menstrual burden and had greater compliance 66% wanted menstrual suppression 44% of OCP users reported difficulty remembering to take it 35% reported insufficient knowledge about OCPs

Powell-Dunford et al. (2011)	USA	Self-report survey	Cross-sectional	IV	Active duty, Reserve or national Guard, deployed in combat operation	500	Menstrual suppression wanted by 66% 78% had used OCPs 21% reported using OCPs continuously while deployed 40% used OCPs at some point during deployment 67% reported compliance problems 45% missed at least 1 pill per week Compliance for continuous users better compared to conventional users Menstrual burden significantly less among compliant users 85% wanted mandatory education for women regarding the use of OCPs for menstrual suppression
Trego (2007)	USA	Semi-structured interviews	Qualitative	NA	Army personnel deployed to military operations	9	Themes regarding menstruation identified: Intensified during deployment Hygiene and self-care difficulties Deployment challenges Inconvenience Military challenges More negatives than positives Menstrual suppression
Menopause							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Haskell et al. (2008)	USA	Participants from existing database, evaluated on oestrogen status	Retrospect-ive cohort	III_2	Veterans	36222	By 2004 66% of sample had discontinued HT use Younger women were less likely to discontinue use
Haskell et al. (2009)	USA	Participants from existing database, compared to randomly selected sample on hormone replacement status.	Retrospecti-ve cohort	III_2	Veterans	836	25% tapered use of HT 75% stopped HT abruptly Tapering use associated with reduced recurrence of menopausal symptoms Women were more likely to taper use if: They had menopausal symptoms Were younger Had been using HT for longer Had higher income

Birth control							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Essien et al. (2010)	USA	Self-report validated questionnaire	Cross-sectional	IV	Female military personnel	346	Condom use in previous 3 months: 63% always used 26% sometimes used 11% never used Condom use significantly associated with: Attitudes and behaviour HIV risk behaviours Social support Demographic factors including marital status, age, number of children, relationship types and employment status After adjusting for all factors, only attitudes and behaviours, relationship type and marital status significant
Manski et al. (2014)	USA	Qualitative in-depth phone interviews	Qualitative	IV	Women who had served in the U.S. military between May 2011- Jan 2012	22	Range of barriers to accessing medical care in deployment settings Confidentiality concerns, lack of female providers, health-seeking stigma No option to access contraception off-base during deployment, citing logistical challenges, inability to travel, and safety concerns Challenges obtaining contraceptive refills and specific contraceptive methods during deployment Only a few participants received pre-deployment counseling on contraception, despite interest in both menstruation suppression and pregnancy prevention
Thomas, Thomas & Garland (2001)	USA	Self-report survey (containing questions about demographics, attitudes to family planning, ship-board stress, quality of job life, depression)	Cross-sectional	IV	Navy Personnel	714 women	Birth control use: 86% of responders 27% OCP, 11.6% depo provera, 2.2% implant, 0.2% IUD, 0.7% diaphragm Most women were comfortable asking for advice 13% reported that their birth control use would be influenced by their partner's wishes

Van Royen et al (2000)	USA	Self-report survey adapted from Henry J Keiser Foundation (1994) to incorporate military specific factors.	Cross-sectional	IV	Active duty military	293	Knowledge of emergency contraception and reproductive issues poor 85% of sample sexually active 62% used birth control 40% good awareness of reproductive cycle While 64% aware of emergency contraception, only 15% understood how to use it Younger unmarried women more likely to use emergency contraception 55% would use emergency contraception if needed
Unintended pregnancy							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Buller et al. (2007)	USA	Retrospective chart review of visits of gynaecological clinic in Kuwait from Augusts 2003-April 2004.	Retrospect-ive cohort	III_2	Female soldiers	1737 health visits	Average age for positive pregnancy test 27 years Amenorrhea primary complaint 92% received ultrasound 77% of pregnant soldiers became pregnant in country 23% arrived in country already pregnant
Custer et al. (2008)	USA	Self-report survey about pregnancy intentions and socio-demographic information.	Cross-sectional	IV	Army women	212	Of live births: 35% were intended 51% were unintended 14% ambivalent These rates are consistent with the upper limits within civilian communities
Goyal et al. (2012a)	USA	Review of existing literature on unintended pregnancy and contraception	Narrative review	NA	Active duty servicewomen, veterans	NA	High rates of unintended pregnancy Low rates of contraceptive use Barriers to contraceptive use: Logistical access issues on deployment Limited knowledge of patient and provider regarding options Prohibition of sexual activity
Grindlay & Grossman (2013b)	USA	Self- report survey responses to DOD Survey of Health Related Behaviors	Cross-sectional	IV	Active duty female military personnel	7225	Unintended pregnancies in previous 12 months: 11% of participants Higher among less educated, non-white, younger, married or cohabiting No impact of deployment
Manski et al. (2014)	USA						

Ponder & Nothnagle (2010)	USA	Review of literature	Narrative review	NA	Military women	NA	Recommendations regarding unintended pregnancy in the US military: Improve access to full range of contraceptive options Remove restrictions to abortion Promote reproductive choice Provide high quality reproductive healthcare
Robbins et al. (2005)	USA	Structured telephone interviews	Cross-sectional	IV	Active duty Air Force women	2348	Pregnancies during 2001: 12% had at least one pregnancy 54% were unplanned 7% of sample had unplanned pregnancies within year Unplanned pregnancies: Approximately 50% due to contraceptive non-use Other reasons include contraceptive misuse and failure
Pregnancy incidence and outcomes							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Araneta et al. (2004)	USA	Deployment and inpatient records from military hospitals and self-report survey.	Retrospective cohort	III_2	Servicewomen from units deployed to Gulf War	1558	Reproductive outcomes similar for deployed compared to non-deployed Ectopic pregnancies and miscarriage elevated among post Gulf War conceptions
Armed Forces Health Surveillance (2012)	USA	Health Surveillance of military personnel deploying October 2001 - December 2010	Retrospective cohort	III_2	US Armed Forces	194956 pregnancies	During the study period (2002-2011) 0.64% of pregnancies for women aged under 49 were ectopic Rates of ectopic pregnancies not significantly different from civilian population. Servicewomen more likely to be surgically than medically treated. Ectopic pregnancies more common in women aged in their 30s and among black non-Hispanic women
Doyle et al. (2004)	UK	Validated postal self-report questionnaire	Retrospective cohort	IV	Gulf war VS non-Gulf war veterans	484 veterans, 377 non-veterans (female)	Gulf war service: No impact on miscarriage risk Unknown impact on stillbirths and birth defects due to insufficient numbers of cases

Kang et al. 2001	USA	Self-report survey	Retrospective cohort	III_2	Army, Airforce, Marine, Navy Vietnam veterans	8280	Among Gulf War veterans compared with controls: Significantly more birth defects among live births No significant differences in stillbirths, infant mortality and pre-term delivery
Katon et al. (2014)	USA	Existing self- report data from DVA National Health Study for a New Generation of US Veterans (nationally representative survey)	Retrospective cohort	III_2	Male and female veterans deployed to Iraq and Afghanistan	20,370 Veterans (16056 men; 4314 women)	Prevalence of lifetime history of infertility was 15.8% for women and 13.8% for men After adjusting for age, ever married, education, ethnicity, component, branch of service, and deployment to OEF/OIF, compared with men, women Veterans had similar odds of lifetime history of infertility (OR =1.07), but increased odds of seeking medical help for infertility (OR =1.35)
Mattocks et al. (2015)	USA	Data from the OEF/OIF/ OND roster file from the DMDC Contingency Tracking System Deployment file of military discharges from October 2001–December 2010	Retrospect-ive cohort	III_2	Women Veterans ages 18-45 who utilized VA health care after military service	68,442	~ 2% received an infertility diagnosis during the study period. Compared with women VA users without infertility diagnosis Those with infertility diagnosis were younger, obese, black, or Hispanic, have a service connected disability rating, a positive screen for military sexual trauma, and a mental health diagnosis 22% of women with an infertility diagnosis received an infertility assessment or treatment 39% of women Veterans receiving infertility assessment or treatment received this care from non-VA providers
Rivera et al. (2014)	USA	Literature review of publications from Vietnam War, Persian Gulf War, and OIF and OEF periods	Literature review	NA	Service women	NA	Female veterans historically report more reproductive and gynecological problems than the general population Experience higher incidences of PTSD and depression compared to male veterans, and overall exhibit a higher prevalence of several mental health disorders compared to the general population

Wells et al. (2006)	USA	Self-reported postal survey	Cross-sectional	IV	Gulf war veterans	8742	Among deployed compared to non-deployed female veterans: No sig. difference in rates of pregnancy, miscarriage and adverse birth outcomes Less risk of any adverse outcome among white, non-Hispanic women 420 reproductive losses
Birth outcomes							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Conlin et al. (2012)	USA	Electronic data from DOD Birth and Infant Health Registry and the Defense Manpower Data Center	Retrospect-ive cohort	III_2	Active duty	13129 women	No consistent association between burn pit exposure on deployment and pre-term delivery or birth defects
Conlin et al. (2013)	USA	Retrospective data from the DMDC	Retrospect-ive cohort	II	Active duty U.S. military women	H1N1 vaccine-exposed n=510376 Seasonal influenza vaccine-exposed pregnancies n=57560	Vaccinated during pregnancy with either the H1N1 vaccine or seasonal influenza vaccine No difference in rates of pregnancy loss, pre-eclampsia or eclampsia (5.8% vs. 5.2%) or preterm labor (6.5% vs. 6.2%) No significant differences in rates of preterm birth (6.2% vs. 6.3%), birth defects (2.1% vs. 2.0%), fetal growth problems (2.6% vs. 2.4%), or male-to-female sex ratio (1.05 vs. 1.07) Rates of all outcomes were lower or similar to overall general population rates No adverse pregnancy or newborn health outcomes associated with pandemic H1N1 vaccination
Evans & Rosen (2000)	USA	Self-report survey	Prospective cohort	II	Pregnant active duty	269	Greater risk of pre-term delivery: Separated or divorced Single These differences may be attributable to other demographic correlates: Lower rank, ethnic minority, greater number of medical conditions, less educated

Greer et al. (2012)	USA	Self-report demographic /weight data 1 year pre-pregnancy, exercise during/after pregnancy	Prospective cohort	II	Marines and Navy women	1409 (1163 Marines, 246 Navy)	Marines compared to Navy Significantly greater likelihood of spontaneous vaginal delivery Mean infant birth weight significantly lower
Hourani & Hilton (2000)	USA	Self-report Reproductive Health Survey	Case control	III_3	US Navy active duty women	336 cases, 696 controls	Adverse live-birth outcomes associated with: Self-reported exposure to heavy metals, petroleum products, pesticides, and other chemicals
Kang et al. (2000)	USA	Self-report survey conducted by telephone	Retrospective cohort	III_2	Gulf War veterans and non Gulf War veterans	3000	Among Vietnam veterans compared with controls: Significantly more moderate to severe birth defects among live births No significant differences in infant death, stillbirth, pre-term delivery or low birth weight
Kang et al. (2001)	USA						
Ryan et al. (2011)	USA	Electronic data from the DOD Birth and Infant Health Registry	Retrospect-ive cohort	III_2	Military women	63056	Deployment during first trimester of pregnancy, at any time during pregnancy compared to no deployment: No greater odds of pre-term birth, malignancy diagnosis, or birth defects
Wells et al. (2006)	USA						
Post-pregnancy Health and Wellbeing							
Author (Year)	Country	Measurement	Design	Level Evidence	Population	Sample size	Key Findings
Appolonio & Fingerhut (2008)	USA	Self-report survey	Cross-sectional	IV	Active Duty	526	19.5% reported symptoms of postpartum depression The following variables were associated with postpartum depression: Low self-esteem, prenatal anxiety, prenatal depression, history of depression, poor social support, poor marital satisfaction, life stress, child care stress, difficult infant temperament
Armitage & Smart (2012)	USA	Retrospective data from existing data bases	Retrospect-ive cohort	III_2	Active Duty Air Force	107	6 months postpartum compared with pre-pregnancy: Larger abdominal circumference Longer run time Fewer pushup repetitions No significant difference in situps Fitness assessment pass rate significantly lower

Greer et al. (2012)	USA	Self-reported survey including weight before/after pregnancy	Prospective cohort	II	Marines and Navy women	1409 (1163 Marines, 246 Navy)	One year pre-pregnancy body weight: 79% of Navy within standards 97% of Marines within standards First antenatal visit body weight: 69% of navy within standards 96% of marines within standards 3 and 6 months post-partum body weight: Marines significantly more likely to be within standards compared to Navy
Katon et al. (2015)	USA						
Nguyen et al. (2013)	USA	Self-report survey	Prospective cohort	II	Active duty military	1660	Maternal depression more likely among women who deployed and were exposed to combat after having child No differences in maternal depression among women who had deployed before having a child and those who had not deployed
Stewart (2015)	AUS.	Cross-sectional electronic survey. ADF women identified from PMKeyS data	Cross-sectional	IV	ADF women took MATL during the Australian FY 2006/2007	152	98% ADF women breastfed for ~8 months, returning to work when the mean age of the child was 8.4 months 66% returned to work full-time, with median breastfeeding duration of 7 months Women who returned to work part-time had a longer median duration of 10 months Breastfeeding rates among ADF women compare favorably with the general Australian population until 9 months, coinciding with returning to work after a period of maternity leave
Weina (2006)	USA	Self-report survey	Cross-sectional	IV	Army	52	Physical fitness test scores reduced significantly between pre-pregnancy and post-partum (6 months after birth) Postpartum exercise was positively associated with physical fitness test scores postpartum Pregnancy complications and weight gain negatively associated with physical fitness test scores postpartum

Menstrual regulation and menopause

Research examining menstrual regulation among servicewomen is somewhat limited, predominantly comprising retrospective self-report data, however this does include a number of large administrative database studies, and supplementary qualitative findings. The issues arising most consistently in this area related to the use of Oral Contraceptive Pills (OCPs) to suppress menstruation, particularly within the deployed environment, the real or implied barriers to access and use of OCPs and the lack of understanding about OCPs, particularly in relation to menstrual suppression.

Overall, there appears to be a disconnect between desire to reduce menstrual burden and actual use of OCPs for this purpose.[12] Using OCPs to suppress menstruation may be beneficial in training and deployed environments[13] given that unplanned pregnancy can impede deployability and menstruation has potentially adverse impacts in the deployed environment. Although deployed women have reported positive attitudes toward menstrual suppression, these attitudes rarely translated to behaviour. For example, Powell-Dunford et al.[14] found that among a sample of US active duty servicewomen, 86% wanted to suppress menstruation, particularly during deployment and field training, but only 7% reported using OCPs to do so. Willingness to consider OCPs for this purpose was positively correlated with the self-reported burden of menses in this study, and in fact other research suggests lower reported burden of menstrual symptoms in women who do suppress menses.[15,16] Despite these attitudes, compliance with OCP use can be poor in deployed environments.[15]

Barriers to access and lack of knowledge about OCPs may account for their under-use in women reporting a desire to reduce the menstrual burden.[16-19] In a study of deployed US servicewomen,[20] one third reported being unable to access their desired contraception and 40% had difficulty obtaining prescribed contraception. More long-term methods of contraception including IUDs were unavailable or discouraged. Whether this issue translates to other international contexts is not clear. In addition to access difficulties, Enewold et al.[18] also found a lack of knowledge and understanding about effective OCP use among US servicewomen, particularly among younger women. Older women, in contrast, had greater knowledge about and were more likely to use OCPs. This study also reported inter-service differences in OCP use, with higher rates in the US Air Force compared to Army.

Despite the increasing population and age of female personnel,[1] the issue of menopause is largely unexamined. Of the two studies investigating menopause, while utilising large sample sizes, neither were able to draw conclusions regarding the impact of, or relationship with service. However, as menopause generally occurs before the regular retirement age of sixty five8, it is likely that many women in the armed forces will experience menopause during their career. Importantly, given the association between age and seniority, the potential for functional impact of menopause in senior levels of service should be acknowledged.

Hormone Replacement Therapy (HRT) can effectively reduce adverse impacts of menopause on everyday functioning.[21] Accordingly, Haskell et al.[22] examined both use and discontinued use of HRT among US servicewomen. Women experiencing menopause at a younger age, and those who had accessed Veterans Affairs clinics were significantly more likely to continue use than other women, although the reasons for these differences were unclear. In a follow-up study, Haskell, Bean-Mayberry and Gordon[23] found the majority of HRT users discontinued use abruptly, despite evidence that tapering use is associated with reduced recurrence of menopausal symptoms. Those who did taper their use (thus having less adverse outcomes) generally had higher income and were younger. Given apparent issues of access to hormonal contraceptives on deployment, similar barriers may apply to accessing HRT. Awareness of and access to OCPs and HRT is important in the deployment environment, given their potential functional benefits.

Birth Control

Contraception

The majority of studies examining contraceptive use among servicewomen were cross-sectional, with some retrospective and qualitative studies. The level of evidence available and lack of comparison groups limit conclusions that can be drawn. However, as with menstrual regulation, a number of issues emerged around knowledge, use of and access to birth control measures. While there is evidence supporting use of OCPs as birth control, particularly while on deployment and training, the number of women actually using them is low. Women may also be less likely to use OCPs whilst deployed, despite understanding their potential benefits, again indicating real or perceived barriers to access and use. Together these findings have implications for unplanned pregnancy and gynaecological

presentations on deployment (as well as menstrual regulation).

More generally, US literature points to a gap in contraceptive understanding among military women. Van Royen, Calvin and Lightner[24] found that among active duty US military women, knowledge about emergency contraceptive methods was poor; 85% were sexually active but only 62% used contraception. Although 64% were aware of emergency contraception, only 15% knew how and when to take it, and younger, unmarried women were most likely to have this knowledge. Thomas, Thomas and Garland[25] explored contraceptive use and family planning among active service US Navy women, with only 40% of these using an oral or implant hormonal contraceptive, suggesting reliance on other methods (e.g., condoms). In some cases pre-deployment counselling on contraception may be inadequate, resulting in a lack of knowledge of available methods on deployment and consequent problems with access.[26]

Von Sadovszky et al.[27] found that among US Army women, condom use overall was low, and a number of factors including ease of use and access contributed to higher use. Use was predicted by relationship type, attitudes to condoms and marital status. In contrast, in a study of sexually active US servicewomen stationed in Nigeria,[28] the majority of women reported using condoms, possibly reflecting differences in perceived risk of sexually transmitted infections (STIs). Despite national polices precluding sexual relations on deployment, condom use has a role in reducing unplanned pregnancies and preventing STIs. Importantly, the availability of condoms (as well as other types of birth control) may be limited in the deployed environment. Therefore, improving access and availability is important.

Unintended pregnancy

There is a general consensus that pregnancy is incompatible with deployment.[26] However, regulations regarding pregnancy testing prior to and during deployment vary across international militaries. In the Australian Defence Force (ADF), for example, pregnancy testing is mandated prior to land deployments and recommended (but optional) in the case of maritime deployments. This is not the case in many other militaries, with optional pregnancy testing prior to deployment. However, pregnancy can occur on deployment, and is not necessarily a rare occurrence. Combined with trends suggesting possible impacts of deployment and deployment exposures on conception and in early pregnancy (discussed below), this is an area requiring further research.

The prevalence of unintended pregnancy among servicewomen appears to be inversely associated with age, rank and seniority, and related to contraceptive non-use, misuse or failure.[29-31] Custer et al.[32] found approximately half of pregnancies among US soldiers were unintended. Although this figure is consistent with the civilian population, these rates significantly impact workforce capability because elements of active military service (e.g., deployment) are incompatible with pregnancy. Regarding deployment, Buller et al.[33] reported unintended pregnancies among approximately five percent of US females during deployment to Afghanistan, a number equivalent to those reported during the Persian Gulf War.

Grindlay et al.[34] explored the issue of abortion among deployed U.S. servicewomen. This qualitative study reported a lack of access to abortion while on deployment, which at times led to the unsafe practice of women attempting to terminate their own pregnancies. Similarly, Ponder and Nothnagle[35] reported a lack of access to education regarding contraception, reproductive choice and support for termination of pregnancy. While conclusions regarding pregnancy termination cannot be drawn on the basis of this research, the potential implications of these anecdotal findings are significant in view of known rates of unintended pregnancies on deployment.

Pregnancy Incidence and Birth Outcomes

There is no definitive evidence that active service impacts on pregnancy likelihood, frequency of ectopic pregnancies or miscarriage. However, a small number of studies indicate a potential increased risk of miscarriage among previously deployed servicewomen, and the possibility of increased risk of birth defects. In relation to active service more generally, there could be adverse effects of occupational standing, or noise exposure, which may increase risk of pre-term labour and birth, and sedentary administrative positions, which may be associated with a greater risk of pregnancy complications (see Table 2 for a summary of evidence). Importantly, any conclusions from this research are limited by the small number of studies available.

There is limited research relating to pregnancy likelihood and pregnancy loss (including ectopic pregnancies and miscarriage) among servicewomen, however most studies do utilise large samples, and include control groups. The Armed Forces Health Surveillance Center[36] reported that among US servicewomen deployed to Afghanistan and Iraq, infertility rates increased with increasing

Table 2. Summary of evidence regarding pregnancy and birth outcomes

Exposure type	Evidence	Outcome				
		Fertility issues	Ectopic pregnancy	Miscarriage	Pre-term birth	Birth defects
Level of activity	Yes				X	
	Mixed					
	No	X	X	X		X
Deployment	Yes		X			
	Mixed	X		X		X
	No				X	
Occupational exposures	Yes					X
	Mixed				X	
	No	X	X	X		

deployment number and length. Menstrual disorders (potentially a precursor to fertility issues) were also more common among females deployed longer than nine months.

Although there is no conclusive evidence that active service impacts on the frequency of ectopic pregnancies or miscarriage, trends from a large administrative data study suggest a potentially increased miscarriage risk among US servicewomen deployed to the Gulf War.[37] Araneta et al.[38] and Wells et al.[39] reported no significant impact of Gulf War service on rates of conception, but Araneta et al. did find increased prevalence of post-deployment ectopic pregnancy and miscarriage. They argued that these higher rates of reproductive losses could be partially explained by demographic risk factors including socio-economic status, however.

A review by Rivera et al.[40] showed that female veterans historically report more reproductive and gynaecological problems than the general population. In addition they are more likely than their male counterparts to seek care for infertility. Increasing numbers of US female veterans are seeking reproductive health care through the Veterans Affairs, yet little is known about the delivery of infertility care for this population.[41] Two large studies utilising Department of Defence and Veterans Affairs data, examined infertility among US servicewomen. Katon et al.[42] found no significant difference in rates of infertility among veterans compared to civilians, however they did find that female veterans were more likely to seek infertility treatment. Mattocks et al.[43] reported that only 2% of US women veterans of Iraq and Afghanistan operations actually received infertility diagnoses, and less than a quarter of these women received infertility treatment.

Literature suggests that demographic factors may be more important predictors of birth outcomes than military service factors such as active duty, occupational exposures, vaccination and deployment; however, emerging evidence does indicate the possibility of service impacts. There is insufficient evidence from the studies to determine definite impacts of active service generally, or the specific impact of deployment on adverse pregnancy outcomes including pre-term birth and birth defects. There is limited evidence that active service may impact preterm birth. However, available evidence does indicate that deployment probably has an impact on pregnancy and birth outcomes more generally, while occupational exposures may have an effect on birth outcomes more specifically (see Table 2).

The limited research into the impact of service on birth outcomes has produced mixed findings. Compared to a control group of civilian dependents of military servicemen (thus subject to the same healthcare access and conditions), active duty servicewomen reported similar birth outcomes including infant weight and gestational age.[44] Of note, this prospective study found that active duty servicewomen had significantly less social support and worked longer into their pregnancy compared to civilian women – further suggesting these factors did not impact on birth outcomes. However, women who engaged in higher levels of occupational activity can have increased risks of pre-term delivery, even after accounting for age, socioeconomic status, marital status and education.[44] Consistent with this, Greer et al.[45] reported that female US Marines were significantly more likely to have a spontaneous

vaginal birth, with babies of lower birth weight, compared to Navy women; inter-service differences in activity levels may explain this finding.

The effect of occupational exposures is also unclear. Hourani and Hilton[46] reported no significant association between occupational 'burn pit' exposures and pre-term birth among deployed US active duty servicewomen. However, odd ratios for adverse birth outcomes appeared consistently higher for women who had been deployed and exposed to burn pits during their pregnancy. This trend is inconclusive but suggests the need for further monitoring. Interestingly, in this same study a significant association was observed between paternal burn pit exposure and risk of birth defects for the subsequent pregnancy. However, the authors noted these findings were inconsistent with others and had no biological explanation. Therefore, this finding should be interpreted with caution. In examining the impact of active duty-related exposures among US navy women, Hourani and Hilton[46] and Conlin et al.[47] found self-reported exposure to heavy metals, petroleum products, pesticides, and other chemicals, were associated with adverse birth outcomes, although these effects were largely accounted for by maternal health variables. Consistent with findings reported by Hourani and Hilton,[46] after controlling for health and pregnancy related variables, the only significant exposure effect on birth outcomes in this study was paternal exposure to pesticides – which was associated with increased risk for pre-term birth. Conlin et al.[48] also reported no adverse pregnancy or newborn health outcomes among active duty US military women who received pandemic H1N1 vaccine during pregnancy.

Likewise, the impact of deployment on pregnancy and birth outcomes is also unclear. Conlin et al.[47] and Ryan et al.[49] reported no differences in rates of pre-term birth, infant malignancies or major birth defects among infants of women who deployed during their first trimester of pregnancy, compared with those who did not deploy. Wells et al.[39] found no significant difference in the rates of adverse birth outcomes for Gulf War deployed female veterans, compared to a non-deployed comparison group. Doyle et al.[50] were unable to determine any association between Gulf War deployment and stillbirths and malformations among the offspring of British servicewomen, due to limited sample size. However, Kang et al.[37] did report a significantly greater risk of birth defects among Gulf War veterans compared to a control group, and in earlier research they found increased risk of birth defects among female Vietnam veterans.[51] Together these findings highlight the need for future research regarding birth outcomes in servicewomen.

Post-pregnancy health and wellbeing

There is a dearth of research focussed on post-pregnancy health and wellbeing among servicewomen. There is little information on breastfeeding rates, workforce retention and post-partum return to work in this population, although recent data is emerging from Australia. This significant research gap has important policy and workforce implications regarding the appropriate supports for and needs of new mothers in the military. The lack of research in this area limits the assessment of evidence, however, it appears that military weight requirements may be unrealistic for new mothers, postnatal mental health issues require further research in this population, and support for breastfeeding may need to extend into the return-to-work period.

Some studies have examined post-partum physical fitness in servicewomen. Armitage and Smart[52] reported poorer performance and lower fitness pass rates for US active duty Air Force women 6 months post-childbirth, compared with participants' pre-pregnancy fitness test results. Further, Armitage and Smart[52] and Weina[53] found that post-partum fitness scores were significantly associated with post-pregnancy complications and weight gain. Overall, the physical fitness of women in the US military services reduces significantly between the pre-pregnancy and post-partum testing. Interestingly, Greer et al.[45] compared weight standards pre- and post-pregnancy among US Marines and Navy servicewomen. Approximately one year pre-pregnancy, almost 80% of Navy women and 97% of female Marines were within accepted body weight standards. At the first prenatal visit, the proportion of Navy women within accepted standards fell to near 70%, while for Marines it remained largely unchanged (96%). Consistent with this, at 3 and 6 months post-partum, Marines were significantly more likely than Navy women to meet body weight standards, again suggesting an inter-service difference.

Appolonio and Fingerhut[54] examined post-partum depression (PPD) among active duty US servicewomen and found almost twenty percent had PPD symptoms. A number of psychosocial variables were associated with PPD diagnosis, including poor social support, life stress and childcare stress. While rates of PPD in the military sample were elevated compared to those observed in the community, no military specific factors were found to significantly predict PPD. However, given the higher rates of PPD in the military sample, further research is warranted. In studying the impact of previous childbirth on the psychological health on deployment, Nguyen et al.[55] found maternal depression was increased among mothers subject to combat exposure while deployed.

This finding suggests that deployment could be associated with increased adverse outcomes for mothers versus non-mothers, though the underlying mechanisms are not clear.

While few studies have examined the impacts of breastfeeding in military environments, Appolonio and Fingerhut[54] reviewed evidence regarding service-related risks to breastfeeding mothers in the British Army. There was limited evidence that lead and pesticide exposure posed a risk to the offspring of breastfeeding mothers, with a recommendation that breastfeeding servicewomen be excluded from duties where these exposures are likely, including environmental duties and working in firing ranges. A recent Australian military study investigated breastfeeding initiation, prevalence, and duration in a cohort of working mothers.[56] Breastfeeding rates among this cohort compared favourably with women in the general population until 9 months, coinciding with returning to work post-leave. Australian servicewomen are entitled to maternity leave as a condition of service, which may have affected initial breastfeeding rates in this study and the proportion of women continuing to breastfeed until maternity leave had elapsed.

Summary and conclusions

In summary, despite limited extant knowledge regarding sexual and reproductive health impacts of military service among women, a number of key issues were identified. There appear to be issues with knowledge of, access to and compliance with oral contraceptives among servicewomen, with two associated implications being rates of unplanned pregnancies on deployment and relief of menstrual burden through contraceptive suppression of menses. While the evidence regarding menstrual burden was mostly anecdotal, there are indications that this could be problematic in austere environments such as the Middle East. By addressing poor contraceptive knowledge and access among female personnel, menstrual burden and unplanned pregnancy could be reduced. There is some evidence indicating deployment may impact on pregnancy and birth outcomes, however it is unclear whether this is due to deployment exposures or other factors that persist post-deployment. Data trends suggest an association between active service and miscarriage, however this is statistically inconclusive. In relation to birth outcomes, evidence suggests a trend towards higher rates of birth defects among offspring of previously deployed women, although this is less the case for contemporary Middle East deployments. Again, this evidence in inconclusive, however it suggests the need for further research in this area.

There were a number of notable gaps in research and evidence. The area of menopause and post-menopause health in the female military workforce was a clear omission. These issues are important given the increasing numbers and age of the female military workforce, and the likelihood that menopausal and post-menopausal women will remain in the workforce longer. More striking, fertility was only examined in two studies, and only then as a secondary outcome. The dearth of research examining impacts on fertility is surprising, although both gaps could be attributable to the age of the cohort. Most deploying females in the US are relatively young and may not yet have encountered fertility issues or menopause, but these areas will become more significant as increased numbers (and ages) of women deploy in operational roles, and their roles expand. Furthermore, with insufficient data from other countries and differing demographic profiles of servicewomen, it is not possible to determine whether fertility issues exist. Growing evidence of the potential burden of menopause, and the various environmental exposures that may adversely impact fertility, indicates these topics will be extremely relevant into the future. Finally, while post-childbirth health and wellbeing was addressed in the context of mental health, and briefly in relation to physical fitness, there was a distinct absence of research regarding breastfeeding among servicewomen. Given the extent of research focussed on pregnancy outcomes, the lack of studies in the area of post-childbirth health and wellbeing is conspicuous. With an increased drive to retain mothers in the workforce, more research in this area is required.

In addition to examining active service impacts more generally, the studies in this review examined the effects of deployment to the Persian Gulf, Iraq and Afghanistan. It is important to note that, except where otherwise specified, findings related to deployment impacts from one area are not necessarily applicable to other areas. Similarly, where findings are specified for Army, Navy, Air Force or Marines, these may not be transferable to other services. Indeed, a number of studies showed significant service specific differences in health outcomes for servicewomen.

Taken together, this review highlights the limited available research relating to the impacts of military service on the sexual and reproductive health of servicewomen. The majority of reviewed studies fell into NHMRC evidence category III-2 or below including a considerable body of qualitative research. Only four included papers were of evidence category II or above (Controlled trials, with and without randomisation). With the exception of one Australian

study, the remainder were from the United States. This disparity reflects the higher numbers of females in the US already in combat and deployed roles, and their increased focus on health surveillance. However, it also highlights issues in terms of generalisability and current gaps in research and understanding relevant to the experience of other countries, including Australia.

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Malaria Outbreak Aboard an Australian Navy Ship in the Indian Ocean

G. C. Rose,[1] N. Westphalen,[2] G. D. Shanks[3]

Abstract:

Four sailors aboard HMAS *Newcastle* were infected with falciparum malaria during a port visit to Dar-es-Salaam in Tanzania. All four were successfully treated at sea with oral atovaquone/proguanil. Besides their apparent non-adherence with the usual antimalarial precautions, the key aspects of this outbreak include a lack of on-board definitive diagnostic capability and treatment, both of which have since been addressed for other Fleet units. Although some Royal Australian Navy (RAN) deployments have lower malaria risk, this is not true for East Africa. All Australian Defence Force (ADF) medical officers need to be aware of falciparum malaria, as one of the few infections that can rapidly kill adults.

Key words: malaria, falciparum, Royal Australian Navy, Indian Ocean

Introduction:

Febrile persons returning from Africa have a very long list of differential diagnoses including common (e.g. influenza) and uncommon (e.g. Yellow Fever) viral, rickettsial (e.g. African tick typhus), bacterial (e.g. typhoid fever) and parasitic (e.g. falciparum malaria) infections. Although all of the examples listed are potentially lethal, falciparum malaria is the only common infection that can rapidly (1-3 days) kill non-immune travellers such as military personnel.

For this reason, early consideration should always be given to malaria in the management of any febrile patient from a malaria endemic area. Although many of the more recent Australian Defence Force (ADF) overseas deployments ashore have been to areas with no (Iraq) or limited (Afghanistan) malaria risk, the risk varies far more widely in the Australasian region from very low in Vanuatu to very high on the north coast of Papua New Guinea (PNG). Furthermore, most ADF malaria cases ashore in recent years have been caused by relapsing (*Plasmodium vivax*) malaria weeks to months after they return to Australia, rather than the more lethal and acute onset *Plasmodium falciparum*.[1]

The risks associated with maritime operations in malarious areas depend on the type of operation being undertaken. The Royal Australian Navy (RAN) often conducts extended littoral maritime operations very close inshore (within mosquito range, typically less than 1-2 nautical miles). Examples include RAN personnel conducting hydrographic surveys off northern PNG, and clearance divers conducting explosive ordnance disposal tasks in Bougainville and the Solomon Islands (although the latter tend to be shore, rather than sea-based).

Ships conducting offshore maritime operations are only exposed to malaria risk during port visits in malarious areas which are typically of short duration (four days or less), and usually involve ports where the risk is low. Although ships undertaking these visits require the same antimalarial precautions as for extended littoral operations close inshore, they are usually only required for the duration of each visit, rather than the whole deployment. All personnel undertaking maritime deployments are briefed on the relevant health hazards in accordance with Australian Fleet standard operations, usually with additional deployment-specific guidance and reinforced by port-specific health briefs prior to each visit.

RAN units undertaking Operation MANITOU conduct counter-piracy and interception of narcotic-running dhows along the eastern coast of Africa. When not engaged in operations, these Fleet units will visit a variety of ports, most of which have no or minimal malaria risk. (Figure 1) See Malaria Atlas Project (http://www.map.ox.ac.uk/) for global malaria estimates. However, malaria chemoprophylaxis is required for port visits to endemic malarial countries on the East African coast. Although preventive measures sometimes fail, most ADF malaria cases result from individual non-adherence. Four such failures recently occurred aboard HMAS *Newcastle* following a port visit to Dar-es-Salaam, Tanzania. (Figure 2) This highly unusual event highlighted several issues for future ADF deployments.

Figure 1: Approximate Zone of Operations for OP MANITOU

Figure 2: HMAS *Newcastle*, an Adelaide class frigate, while at sea. (ADF photo)

Outbreak Description:

During 10-14 June 2015, four sailors presented to HMAS *Newcastle's* sick bay with fever, malaise, dehydration, nausea, headaches and fatigue over some days. They were given symptomatic treatment for fever, excused duties and sent to rest in their mess. All four members had returned from shore leave at the same hotel during a port visit to Dar-es-Salaam, Tanzania 26-29 May 2015, where they had extensive outdoor night time exposure to mosquitoes. Despite all crew members receiving warnings that malaria was endemic in Dar-es-Salaam and advice provided regarding appropriate long sleeve clothing to be worn during dawn and dusk, sleeping under mosquito nets if sleeping outside, use the supplied mosquito repellent and direction to take malaria chemoprophylaxis (doxycycline), no precautions were taken to reduce the risk of malaria by the sailors involved.[2]

On 15 June 2015 the medical officer HMAS *Newcastle* contacted the Australian Army Malaria Institute (AMI) at Gallipoli Barracks in Brisbane requesting advice for these sailors, who now had fevers to 40˚, dehydration, headaches, abdominal pain and vomiting. The medical officer also made contact with the Fleet Medical Officer (FMO) over the course of the day, for advice on the short to intermediate term management if evacuation was needed. Two members had become visibly jaundiced and were admitted to sickbay, where they were rehydrated with intravenous fluids, treated symptomatically with antipyretics and monitored by the medical team overnight. The rest of the crew were screened for symptoms and no other cases were found.

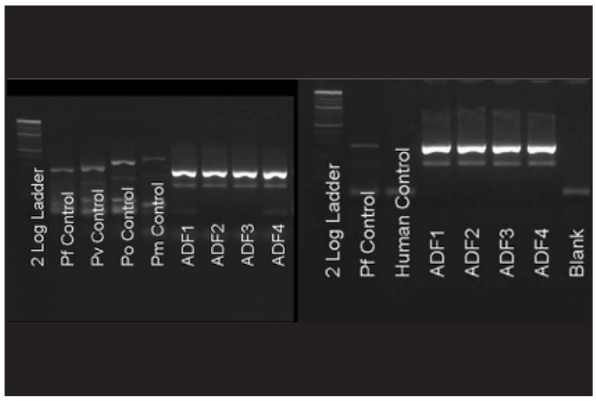
Although malaria rapid diagnostic tests are available for a ship deploying to malarious areas, they are not considered critical items, nor are they listed as accountable items on the medical allowance list (MAL) and so were not routinely carried out and thus not ordered prior to departing Australia. Furthermore, although the on-board chemical analyser (iStat™) was considered a critical item, the cartridges that allowed for rapid laboratory testing were not obtained in Australia prior to departure as they were also not deemed critical.

On 16 June 2015 blood was taken pre-treatment for later diagnostic testing, and all four cases were commenced on oral atovaquone/proguanil, Malarone® (1000 mg/400 mg) daily; the only one of the three antimalarial drugs on board (others were primaquine and doxycycline) that could be used to treat falciparum malaria. Although by then all four cases were jaundiced, they had significantly improved by the second day of treatment, beginning to eat again, feeling less dehydrated and their headaches settling. By treatment day three they were clearly improving and they were afebrile by treatment day four. Three of the four cases returned to normal duties by treatment day seven and the fourth returned to duty on treatment day eight. Following advice from AMI, a two week course of primaquine was commenced on treatment day two (16 June 2015), in order to eliminate the risk of relapsing malaria. At the next port visit on treatment day eleven (26 June 2015) malaria rapid diagnostic tests and additional malaria treatment medication (artemether/lumefantrine, Coartem®) were obtained by special courier delivery. Blood taken at the time of illness was positive for falciparum malaria by rapid diagnostic test.(SD BIOLINE™ Malaria Ag P.f/Pan) (Figure 3) Definitive confirmation of the diagnosis of acute falciparum malaria was obtained by polymerase chain reaction of residual nucleic acid at AMI. (Figure 4)

Issues related to malaria rapid diagnostic tests, and treatment medications were raised at the FHD

Figure 3. Rapid diagnostic tests showing that the four sailors were infected with *Plasmodium falciparum*. Test is SD BIOLINE Malaria Ag P.f/Pan.

Figure 4 Electrophoresis gel showing DNA bands diagnostic of falciparum malaria in all four sailors (ADF1-4 compared to Pf Control).



Medical Allowance List Working Group (MALWG) on 13 July 15. All MALWG recommendations are reviewed by the FMO and approved by Director, Navy Health (DNH) and compiled for a quarterly published update to the Fleet. In this case, the MALWG agreed to update the MAL to reflect current ADF guidance, by adding artemether/lumefantrine, Coartem®.[2] Although this guidance is not publicly accessible through the ADF intranet, the treatments recommended approximate current malaria treatment guidelines from the World Health Organization (http://www.who.int/malaria/publications/atoz/9789241549127/en/).

Discussion

Falciparum malaria has an approximately 48-hour cycle, with a ten-fold multiplication each cycle.[3] One can therefore estimate that these sailors were 1-2 days from requiring urgent medical evacuation and 3-4 days from death if not treated. Antimalarial precautions such as mosquito netting, long clothing, insect repellent and chemoprophylaxis must all be employed in order to be effective. Non-adherence is partially due to perceptions of invulnerability common among young men, as well as uninformed reading of internet reports describing an infinite number of adverse events following some antimalarial chemoprophylaxis regimens (typically mefloquine). Practical experiences such as this event, if communicated properly to ADF members, may facilitate better adherence with antimalarial precautions in the future. Even so, this event is considered highly unusual, noting there have not been any known cases of malaria among Navy personnel undertaking seagoing operations (as opposed to those ashore) at least since the early 1960s.

Although HMAS *Newcastle* was authorised to be supplied with malaria rapid diagnostic test kits, they were not available for use when needed and were not considered critical for this deployment. Furthermore, despite having the correct laboratory equipment to conduct limited hepatic and renal function monitoring, no consumable supplies to actually perform them were embarked. As a result, the medical officer's ability to diagnose these four malaria cases was limited to clinical findings.

Although these issues have since been addressed, this event demonstrates some of the generic risks associated with providing health support for maritime operations that require active management, and the role of Navy medical officers with respect to managing these risks. Even so, timely evacuation remains the only option for RAN and other ADF deployments that do not have a medical officer or malaria diagnostic and treatment capability. Medical officers must take all febrile illnesses following travel to Africa seriously and arrange to rapidly rule out treatable aetiologies such as malaria. Recent failure to understand the malaria risks in Africa in other military forces has resulted in severe illness including deaths and multiple air evacuations.[4,5] Although all febrile patients returned from Africa do not have malaria, it is important to quickly ascertain if any such individual has malaria, as it remains a very treatable infection if medications are given in time.

Contributors: Author GCR managed the patients while author GDS provided advice and author NW provided Navy-specific input.

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Disclaimer: The opinions expressed are those of the authors and do not necessarily reflect those of the Australian Defence Force.

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The Mosquito can be More Dangerous than the Mortar Round - The Obligations of Command

A. M. Smith, C. Hooper

We must be prepared to meet malaria by training as strict and earnest as that against enemy troops. We must be as practiced in our weapons against it as we are with a rifle.

FIELD MARSHAL VISCOUNT SIR ARCHIBALD WAVELL

These words, penned in 1943 by the commander in chief of British forces in Burma during World War II, underline the reality that losses to malaria and other preventable diseases among Allied forces operating in the China-Burma-India theater far exceeded the number of casualties inflicted by enemy action.[1] Today, as the global war on terrorism evolves, a similar failure to appreciate noncombat environmental threats—including mosquitoes and other diseasecarrying insect vectors—will once again degrade combat effectiveness of deployed forces. The significance of Field Marshal Wavell's caveat was amply demonstrated in August 2003, when a U.S. Marine Corps team, while conducting stabilization operations in Liberia, was hit by a surprise disease outbreak.

Almost 30 percent of the deployed military personnel contracted malaria, distracting military medical assets already committed to supporting combat operations in Iraq and Afghanistan.

Deployment Risks

Disease and illness will likely generate more casualties than combat during military operations along the African littoral, in South Asia, or on East Asian shores. Up to 75 percent of the casualties suffered in previous conflicts in these regions resulted from disease.[2] Examination of U.S. Marine casualty data from Vietnam alone reveals that only a third of hospital admissions were for wounds incurred as a result of combat action; two-thirds of hospitalized personnel suffered from diseases and, in lesser numbers, nonbattle injuries.

Malaria is a particular risk. Though the mosquito-borne disease has long been eliminated from the United States, it remains, according to the World Health Organization, one of the most significant health threats in the world. *Plasmodium falciparum*, the most severe and life-threatening form of malaria-causing parasite, kills more than a million people a year. The danger to American military personnel is twofold. Malaria victims who have never been previously exposed to malaria-causing parasites are at high risk of suffering acute infections. Symptoms of acute infection begin nine to fourteen days after an infectious mosquito bite; they are characterized by rapid onset of debilitating fever, headache, vomiting, or other flu-like symptoms that can be accompanied by life-threatening complications. If the victim survives a first bout of malaria without treatment, the infection then becomes a persistent health problem. Chronic, longer-term malaria infection causes successive bouts of severe fever that, if still left untreated, results in progressive deterioration and possible death.

The malaria threat is tied to the rate of transmission, and in most cases the transmission rate depends on the local mosquito population. During operations in sub-Saharan Africa, where mosquitoes are very effective malaria "vectors," malaria infection rates among unprotected troops may be expected to approach 100 percent, and if the infected soldiers are American, without prior exposure to tropical diseases, a high percentage will likely suffer acute infections and experience life-threatening complications that require immediate medical evacuation. These realities could easily render a U.S. military force ineffective without a combat engagement ever taking place.

But malaria and other insect-carried diseases are not the only threats. Military medical-care responsibilities for indigenous civilian populations bearing other communicable diseases unique to their regions could further impact the military medical-evacuation chain. Likewise, although it is not an acute phenomenon, the human immunodeficiency virus (HIV) has profoundly altered the medical risk to troops deployed worldwide. Disease is a constant battlefield threat that, if command engagement and interest are lacking, will endanger America's ability to project military power.

The Marines Enter Liberia

Despite long international experience with expeditionary military engagements in Africa and a thorough understanding of the malaria threat, a significant proportion of Joint Task Force personnel inserted into Liberia in August 2003 (eighty out of 290 who had been ashore) experienced symptoms of malaria. The actual malaria "attack rate" will never be known, since the entire contingent began anti-malarial treatment soon after medical authorities determined the causal agent. A number of latent, "incubating" infections probably went undetected as asymptomatic soldiers rushed to take anti-malarial medication. At any rate, the outbreak was a blow to combat effectiveness, and though there were no fatalities, several victims developed a dangerous complication, cerebral malaria. In cerebral malaria, the blood vessels that carry blood to the brain are clogged, and victims require mechanical lung ventilator support, intensive-care units, and rapid medical evacuation to survive.

What could explain this debacle? Why did most deployed participants—primarily Marines of the 26th Marine Expeditionary Unit (MEU) Quick Reaction Force from the USS *Iwo Jima* (LHD 7) Amphibious Ready Group (ARG)—become infected?

> *Failure to control malaria destroyed the combat effectiveness of "Merrill's Marauders" in Burma, in 1944. The loss rate was unsustainable.*

Investigators focused on a number of questions: Was the outbreak due to failure of commanders to ensure that members of the landing force took the prescribed anti-malarial medication, Mefloquine, for the necessary duration of time prior to their insertion into Liberia? Were the deploying forces properly trained to operate in a nation where insect- and water-borne diseases are everyday occurrences? Did the Defense Intelligence Agency's Armed Forces Medical Intelligence Center fail to warn commanders of the Iwo Jima ARG about the locally high rate of malaria transmission? Did Marines, having heard about a rumored association of Mefloquine with violent psychiatric reactions in returning Army Afghanistan veterans in Fort Bragg, North Carolina, willfully avoid their antimalarial medication? Finally, could the prophylactic (preventive) agent have been manufactured incorrectly?

A consensus conference at the Navy Bureau of Medicine and Surgery on October 9, 2003, revealed that the major contributory factors to the outbreak included insufficient intake of anti-malarial medication and a wholesale failure to employ protective measures.[3]

Blood samples taken from the 26th MEU showed that only 5 percent of affected personnel regularly took Mefloquine. Blood samples from 133 Marines were tested for Mefloquine levels at the U.S. Centers for Disease Control and Prevention (CDC). Seventy percent contained breakdown products of the drug, itself evidence that some Mefloquine had been taken in the preceding month, but only 14 percent had levels high enough to be effective at the time of insertion into Liberia. Only 5 percent of the samples indicated that the medicine had been taken every week. Analysis of Mefloquine taken from Marines' pockets revealed that the potency and formulation of the drug were adequate.

Logistical problems were responsible for some of the other failures. For example, the 26th MEU had ordered bulk Permethrin insecticide for uniform treatment before deployment, but the unit did not receive the Permethrin prior to departure from the United States. Instead, the unit received spray cans of the insecticide, which were then used to treat the desert-camouflage uniforms that the troops had worn in their earlier deployment to the Middle East. In Liberia, however, woodland-camouflage uniforms were worn, and only 12 percent of the troops treated those. Only 27 percent reported using the time-released insect repellant issued to them, and, making matters worse, none slept under insecticide-treated mosquito nets. The Liberia expedition was a "man-portable mission," in which each individual had to carry everything he needed from the transport to the deployment site. Permethrin-treated sleeping nets—a low-tech item previously shown to dramatically cut malaria mortality in West Africa—were not even taken ashore. In addition, many troops were reluctant to use the long-acting insect repellant DEET on the grounds that the repellant was too greasy for hot-weather operations.

The epidemiologic investigation concluded that better malaria-awareness training and wider access to anti-malaria equipment are the best ways to prevent future malaria outbreaks during deployments. Ironically, identical historical lessons, emphasizing the importance of individual, group, and command discipline, have been learned repeatedly since malaria was identified as a major degrading factor in military operations; all appear to have been forgotten. The Navy and Marine Corps have neglected the war fighter's long and proud disease-fighting legacy.

Burma 1943

The Burma campaign in 1943 was a particularly brutal sideshow of World War II. But here, fighting under terrible conditions and at the end of a dauntingly long supply line, soldiers served in what can be seen now as a battle laboratory.

Their experience laid the tentative foundations for today's joint, combined, and special warfighting strategies. Unfortunately, the innovative tactics explored in the China-Burma-India theater were ignored for years after the war, and few looked to exploit the innovative warfighting strategies pioneered in this marginally successful theater of operations, much less recognized that the ravages of preventable disease had bogged down the pace of operations.

Wingate's "Chindits"

Major General Orde Wingate, a commander of the "Chindit Special Force" (and a British military innovator) pioneered a brutal training regimen that quickly shaped soft, poor-quality infantry into a cohesive counterinsurgency-capable force. Since the Chindits were expected by their commanders to endure all physical challenges, disease prevention was deemphasized.

Even during training, fundamental rules of sanitation and basic anti-malaria precautions were ignored. That neglect caused serious losses; within a period of six weeks one brigade lost over 70 percent of its soldiers to malaria-related hospitalization. Wingate, a survivor of cerebral malaria, used his experience to downplay the importance of antimalarial measures.

> *The importance of individual, group, and command discipline has been learned repeatedly since malaria was identified as a major threat to military operations; the lesson appears to have been forgotten.*

One soldier recalled, "In one respect we had the wrong attitude to Malaria; we looked on it as inevitable; we believed that we were all bound to get it every so often....[W]e never treated Malaria as a disease meriting evacuation. This prejudice ultimately became a self-fulfilling prophesy.

In some respects, the training befitted the Chindits' difficult mission. The Chindit Special Force operated as a commando unit, tasked to infiltrate Japanese lines and conduct hit-and-run attacks against exposed railroads and bridges essential to enemy operations. The soldiers were expected to be constantly on the move, fighting without a base and supplied largely by air. The troops were initially provided with anti-malaria equipment—full green battle dress, anti-mosquito cream, head veils, arm-covering cotton gauntlets, and the anti-malarial medicine of the day, Mepacrine—but these force-protection measures crumbled under the extreme operational conditions and because their leaders believed that disease could be overcome by endurance rather than prevention.[5]

Full, extremity-covering uniforms were discarded, offering ample opportunity for malaria-carrying mosquitoes to bite and transmit malaria. The men preferred shorts to long trousers, especially when maneuvering in Burma's broken terrain; some cut most of the trouser legs from their battle dress. Sleeves were rolled up and uncomfortable arm-covering gauntlets discarded. Anti-mosquito veils were both ineffective and dangerous, offering little protection to sleeping soldiers and restricting vision during night operations.

Chindits rarely had organized and insect-free sleeping quarters. For malaria, this was a critical oversight, since most mosquito bites occur at night, when the insect can feed upon unaware and unresisting hosts. Jungle hammocks provided good shelter from rain and a measure of protection from flies, mosquitoes, and other jungle pests. The mere fact that the hammocks were raised off the ground reduced bites from typhus-carrying ticks and mites. Soldiers recognized that hammocks reduced the rate of typhus and malaria, but again, operational drawbacks discouraged universal use. The hammock, when enclosed by a portable mosquito net, was difficult to exit in an emergency; further, the jungle hammock and net weighed seven pounds and was bulky. In general, the jungle hammocks, when available, were reserved for the injured and seriously ill.

> *Eighty out of 290 personnel inserted into Liberia in August 2003 experienced symptoms of malaria.*

The principal anti-malarial medication for World War II was Mepacrine (known among American forces as Atabrine). Though it was relatively effective, it was not fully supported at either the command or field level. Mepacrine had to be pressed into service to replace quinine, a time-tested and accepted anti-malarial medication, because by 1943 the Japanese had seized the quinine-producing areas of Java (Indonesia) and the Philippines. Military medical authorities in India and Burma were initially cautious about using Mepacrine as a prophylactic or suppressive (symptom-reducing) anti-malarial, fearing that the drug's potential to conceal infection would encourage combat leaders to keep men on duty when they were afflicted with the disease. Some medical leaders were also concerned that overreliance upon Mepacrine would lead troops to neglect other aspects of anti-malarial discipline. But the Chindits' failure to adopt basic habits that usually prevent exposure to malaria-carrying mosquitoes put Mepacrine to the test.

Unfortunately for the troops, suppressive treatment with Mepacrine was not carried out with complete efficiency even when the drug was available. No

regular formations and inspections were held to ensure that men took the anti-malarial medication at the times and in the dosages necessary to prevent malaria. Many personnel, in fact, refused to take Mepacrine. A myth that Mepacrine produced sexual impotence or sterility was rampant among all Allied forces. In one battalion the administration of the drug was suspended before troops went into action, because its officers believed the drug would reduce fighting efficiency. Such fallacies had a tendency to spread rapidly, become exaggerated, and gain credibility during circulation.

Deliberate failure to take Mepacrine on a regular and consistent basis led to confidence-eroding "breakthrough infections" when the level of Mepacrine in the blood became too low to control the proliferation of the malaria parasite. One medical officer discovered that the Mepacrine containers of two of his patients who had just died of cerebral malaria still contained the original quota of thirty tablets at a time when they should have been almost empty.

The enormous amount of labor required to reduce local hazards of contaminated water, insect bites, and fungus infections of the skin—indeed the impossibility of preventing them entirely during a long campaign—produced further laxity, bordering upon hostility, toward medical discipline. The admiration of the line community for its own medical assistants was evidently counterbalanced by indifference and even resentment toward medical advice from the rear.

Command indifference to disease prevention denied soldiers the opportunity to exploit incremental improvements in malaria-prevention technology. Mosquito repellent, oil of citronella, was initially issued in an ineffective and greasy formulation. The uncomfortable repellant fell out of favor, and the Chindits resisted later nongreasy and more effective counterparts. Command elements failed to instill confidence in the new formulation, and no organized inspections were held to demonstrate or ensure proper and regular use of the mosquito repellant.

> *The realities of malaria could easily render a U.S. military force ineffective without a combat engagement ever taking place.*

With the passage of time, the incidence of malarial fever attacks rose steadily; few men experienced less than three attacks. The majority had as many as seven malarial episodes—and many had to endure malaria attacks while actively engaged with enemy fighters. The fighting efficiency and morale of personnel who had experienced three or four attacks of malaria diminished rapidly. Dysentery, diarrhea, lung infections, and skin diseases were more likely to infect, and after infection to disable completely, a malaria-ridden soldier, compared with a soldier who had not suffered repeated bouts of malarial fevers. Deaths from cerebral malaria and typhus increased during operational deployments. The Special Force, as a result of its aggressive training and counterinsurgency mission, broke medical discipline, exposing itself to these preventable parasitic diseases. Compounding the failure of disease-prevention measures, members of the Chindit force gave up the suppressive benefits of Mepacrine. The medical officers, facing a situation that appeared insurmountable, gave up, allowing themselves to fall to the low standard set by the men. The casualty rate was enormous. Just two-thirds of the Chindit troops who embarked upon Operation LONGCLOTH in February 1943, a marginally successful four-month incursion into Burma, returned. Ultimately, only six hundred of the three thousand troops who commenced that operation were ever fit for military service again.

From a clinical viewpoint, the Special Force was more severely injured by malaria than by bullets and grenades. Considered tactically, unit battleworthiness was determined more by its state of medical discipline than by courage.[6] It has been said that the Chindit Special Force met a more dangerous enemy in disease than in the Japanese army. Disease did more damage than the enemy. Even Wingate's substantial legacy of innovation was diminished by his failure in Burma to ensure the health of his men.

Merrill's Marauders

U.S. forces in the China-Burma-India theater had similar problems. Like the British, the Americans relied primarily upon Atabrine (Mepacrine) to suppress and control malaria. The members of Brigadier General Frank Merrill's 5307th Composite Unit (Provisional)—known as "Galahad," or "Merrill's Marauders"—self-administered their anti-malarial medication. Each soldier was expected to take a Mepacrine tablet on a daily basis, conforming to a system already developed for the Pacific theaters. But again, many soldiers failed to follow precisely the protocol required if the medicine was to prevent malaria. Atabrine indiscipline became a particularly potent manifestation of the poor morale common in troops en route to the theater and within units experiencing their first weeks of training in India. Unfortunately, command interest in reinforcing individual Atabrine discipline was also lacking, often neglected until malaria brought training to a standstill. Disease made morale even harder to restore.

The Marauders entered Burma in February 1944 with inadequate collective anti-mosquito protection. As with the Chindit Special Force, little was done to control malaria-carrying mosquitoes. Means by which individuals could limit mosquito exposure—repellants and "mosquito bars" (protected sleeping enclosures)—were unpopular and used by only a handful. Predictably, malarial infection and reinfection were rife during operations in the theater. The theater commander, General Joseph Stilwell, exacerbated morale problems by pressing his men to extend offensive operations and placing restrictions on medical evacuation.

Gradually, fatigued and disease-ridden men began to repudiate Atabrine. It was a vicious cycle. The sicker the troops became, the lower the morale. The lower their morale, the less hope there was of restoring Atabrine discipline and curbing malaria.

As reported by a malaria expert on the staff of General Stilwell, the failure to control malaria destroyed combat effectiveness. "It was incumbent upon any medical officer surveying a unit with a current malaria rate of 4,080 attacks/ 1,000 men per annum; with 7.4% of the men noneffective each week because of Malaria; and 57.3% of the remainder infected during the past year, to consider the unit as unfit for operations before adequate rest period and replacement is provided."[7] The loss rate was unsustainable.

Few of the original 2,750 combatants endured the entire campaign. At one point, the Marauders were losing seventy to a hundred men daily to malaria, dysentery, and scrub typhus. By August 1944 only two hundred of the original Galahad force remained, and these were utterly worn out.

> Thus were the Marauders destroyed, not by mis-leadership, although it played a part in the closing phase of the disaster, nor by the enemy… Their destruction occurred on the ridges and jungle trails… Of the three causes of the Regiment's collapse, the environment was the underlying cause. The tactical engagement was the precipitating cause; and the invasion of the troops by disease was the final and decisive cause. To an unknown extent the Marauders helped their enemies by their loose sanitary practices, by command ineptness in supporting the medical establishment, and by defiance of Atabrine suppressive discipline. In the end, disease producing parasites Amoebae (Dysentery) and Plasmodia (Malaria), as well as bacteria and Rickettsia (Typhus) organisms, rather than Japanese soldiers, vanquished Merrill's Marauders.[8]

The Responsibility Of Command

In general, mere mention of hygiene and sanitation elicits tolerant but bored amusement from specialists in the combat arms. To this day, many senior officers are unwilling to accept the fact that hygiene is not only a function of discipline but one of the basic factors upon which discipline is built. Personal discipline aggregates to collective discipline; its absence in the individual produces the same absence in the operational unit.

The recent embarrassing experience with malaria during Liberian operations once again demonstrated the historically validated and fundamental axiom that training in the prevention of disease must be given top priority and be treated like any other battle exercise aimed at attainment of an objective with the least casualties. Training must be sufficiently intensive to ensure that all personnel can be relied upon to maintain personal hygiene, unsupervised, during any period of active operations. Without this, morale and fighting effectiveness will crumble.

Malaria is a particular challenge; aside from the intake of suppressive medications, strict anti-malaria discipline must be enforced during training periods, and any breach sanctioned. If compliance with expected anti-malarial measures proves unwieldy or unrealistic, a unit commander is obliged to facilitate the development of an engineering or medical solution. In operational theaters where malaria is endemic, administration of anti-malarial medication and compliance with personal and collective force protective measures can be ensured by evening inspections at the first indication of sundown, when mosquitoes are most active. Such measures of personnel protection from mosquito-borne illnesses must be practiced repeatedly until their observance becomes a conditioned reflex.

The importance of effective command discipline was validated by yet another historical example from the jungles of Burma during World War II. Like Wingate's Special Force and others, the British South East Asia Command's Fourteenth Army, in general, faced significant losses to malaria. A new commander, then Lieutenant General Sir William Slim, took over determined to enforce vigorously a malaria-control program in the Fourteenth Army. As he later recalled in his memoirs, "In 1943 for every man evacuated with wounds, we had 120 evacuated sick. The annual malaria rate alone was 84 percent per annum of the total strength of the Army, and

was still higher among the forward troops. A similar calculation showed me that in a matter of months, at this rate, my army would have melted away."[9]

Lieutenant General Slim saw correctly that more than half the battle against disease is fought not by doctors but by regimental officers. Those in direct, regular contact with the troops are best placed to ensure that personal anti-mosquito measures are observed and that daily doses of anti-malarial drug are taken. General Slim initiated surprise checks in which every man in the unit was examined. If men had not taken the drug, and if the overall results of blood tests for the medication within the unit were less than 95 percent positive, Slim "sacked the commander. I only had to sack three; by then the rest had got my meaning." Because of this emphasis from the top,

> slowly, but with increasing rapidity, "as all of us, commanders, doctors, regimental officers, staff officers and [noncommissioned officers] united in the drive against sickness, results began to appear. On the chart that hung on my wall, the curves of admissions to hospitals and Malaria in forward treatment units sank lower and lower until in 1945 the sickness rate for the whole 14th Army was one per thousand per day."[10]

As the recent incident in Liberia demonstrates, the global war on terrorism may become completely paralyzed without a wholesale commitment of leadership, "from the top," to the environmental protection of the troops. Flesh and blood remain the central element of all weapons systems. The will and physical capability to fight remain the crucial factors in any equation for victory. If commanders are unable to recall the hard medical lessons learned in previous conflicts, and fail to ensure the health of their soldiers, how can America expect to confront bioweaponry or other, more dangerous infectious threats?

Standards of hygiene and sanitation are not only indicative of discipline within a unit but are direct personal reflections upon the leadership capabilities of commanding officers and their staffs. Regular care and maintenance of vehicles are essential to trouble-free operation; so it is with human resources during combat deployments. Unless the war fighter's welfare receives constant attention, sickness and ill health are bound to ensue. In units where hygiene and sanitation are poor or lacking, commanding officers have neglected the interest and welfare of their soldiers, and their fitness for command is to be questioned.

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Volume	No	Issue Date	Submission Deadline	Advertising Deadline
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24	4	October 2016	As per AMMA Conference Submission Process	1 September 2016
January 2017 – Aviation Medicine				
25	1	Janary 2017	1 October 2016	1 December 2016
April 2017 – Disaster Relief and Humanitarian Assistance				
25	2	April 2017	1 January 2017	1 March 2017
July 2017 – Mental and Social Well-being				
25	3	July 2017	1 April 2017	1 June 2017
October 2017 – Surgical Innovations in Military Medicine and Conference Abstracts				
25	4	October 2017	As per AMMA Conference Submission Process	1 September 2017

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