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TITLE: Prospective Assessment of Neurocognition in Future Gulf-deployed and Gulf-nondeployed Military Personnel: A Pilot Study

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14. ABSTRACT Purpose: To examine neuropsychological outcomes associated with OIF deployment. Secondary objectives include identification of both deployment-related and non-deployment-related risk and resiliency factors for adverse neuropsychological outcomes. Scope: Prospective cohort design in which deploying Army soldiers are assessed once prior to deployment and twice after redeployment. A comparison group of soldiers is assessed before and after a period of garrison duty. Methods include administration of performance-based neuropsychological measures and self-report surveys. Progress: Time 1 and Time 2 data were collected on all but one small non-deployed unit. Time 3 data have been collected on 3 brigade-level active duty units. Major findings: OIF deployment was associated with disadvantaged memory and attentional performance and increased emotional distress but with advantaged simple reaction time. Unit cohesion buffers the adverse effects of early life events on PTSD prior to deployment.					
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INTRODUCTION

Unexplained health symptoms appear to be ubiquitous to modern war.¹ However, questions remain regarding linkages between military operational deployment and the development of physical or mental health symptoms. An area of particular vulnerability may be neuropsychological functioning. For example, following the 1991 Gulf War (GW), significant subsets of military personnel and veterans reported non-specific health (e.g., headache, fatigue) and cognitive (e.g., memory impairment) symptoms suggestive of possible neural dysfunction.³⁻⁷ Neuropsychological functioning encompasses cognitive (e.g., memory, attentional, reasoning), perceptual-sensory-motor (e.g., motor speed), and emotional (e.g., mood) behaviors thought to reflect neural integrity. Unresolved issues include whether subjective neuropsychological complaints correspond to objectively measured indices; whether neuropsychological problems can be linked to specific environmental exposures, stress exposures, or other deployment-related experiences; and the interaction of deployment with potential risk and resilience factors on neuropsychological functioning.

The work encompassed in this report is now referred to as the Neurocognition Deployment Health Study (NDHS). To help address the gaps in knowledge described above, the NDHS incorporates prospective administration of performance-based measures of neuropsychological functioning in cohorts of Army Soldiers deploying in support of Operation Iraqi Freedom (OIF) and in a similar group of Soldiers before and after an interval of non-deployment. The objectives of this ongoing study are to (a) examine the impact of combat-zone deployment on neuropsychological outcomes, including neurobehavioral and emotional functioning, (b) examine the impact of deployment-related stress and environmental exposures on neuropsychological outcomes, and (c) identify potential health risk and protective factors relevant to neuropsychological outcomes. A secondary objective of the study is to describe select psychiatric outcomes, the importance of which is suggested by high rates of PTSD and other psychiatric disorders following Iraq deployment.²

BODY

Project History

The original SOW described the following elements within a 24-month timeframe:

<u>YEAR 1</u> <u>Phase I</u>		
Task 1	Proposal phase and Week 1	Orient project staff to project tasks, training, set-up
Task 2	Months 1-4	Phase I pre-deployment, baseline assessment & data collection, creation of database
Task 3	Months 5-8	Collection of electronic medical/health care record system databases through data requests, transfer of test data to formats readable by statistical software; data entry
Task 4	Months 9-12	Preliminary analyses of Phase I data collection.
<u>YEAR 2</u> <u>Phase II</u>		
Task 1	Months 1-4	Post-deployment assessment & data collection; collection of electronic deployment-related service information through data requests; data transfer; data entry
Task 2	Months 5-7	Complete collection of electronic deployment-related service information, data transfer, and data file linking of pre- and post- databases.
Task 3	Months 8 – 12	Final data analysis; preparation of reports

However, the SOW was later approved to extend to a 60-month time frame, the final 12 months of which reflect a no-cost extension. The 60-month time frame reflects in part modifications to the data collection schedule associated with the deployment rotations of the military units included in the study and initial delays in the study associated with administrative approvals and identification of appropriate military units. In addition, it reflects the addition of a third data collection point for each unit so that longitudinal stability may be assessed and outcomes expanded to include health behaviors and occupational functioning.

The history of the project is as follows:

Nov 02:	Proposal submitted
Dec 02:	Made contact with US Army Forces Command (FORSCOM) Surgeon's Office
Jan 03:	FORSCOM requests Department of Army letter of support
28 Jan 03:	Final HSRRB approval
31 Jan 03:	MRMC Commander provides DA letter of support
28 Feb 03:	FORSCOM identifies initial units (primarily regular Active Duty, Fort Hood); III Corps requests FORSCOM tasking order
Mar 03:	Start-up funds received
Mar 03:	Assistant Secretary of Defense provides letter of support FORSCOM tasks III Corps Scheduled by III Corps to begin data collection 27 Mar
22 Mar 03:	4 th Infantry Division receives flight orders/opts out of study
3–9 Apr 03:	301 “deploying” Soldiers (1 st Cavalry Division) assessed (Time 1)
14–18 Apr 03:	149 “non-deploying” Soldiers assessed
14 Apr 03:	Deployment orders of 1CD called into question (eventually cancelled)
Aug 03:	FORSCOM identifies two Active Duty Stryker brigades appropriate to study 3/2 SBCT to serve as deploying group; 1/25 SBCT to serve as non-deploying group Intent to deploy 1 st Cavalry Division announced
Nov 04:	3/2 SBCT deploys
22 Sep- 9Oct03:	450 3/2 SBCT and 387 1/25 SBCT Soldiers assessed (Time 1)
Dec 04:	2 nd baseline (Time 1.5) conducted on 1 st Cavalry Soldiers to provide assessment more proximal to actual deployment
Feb 04:	1 st Cavalry deploys
May 04:	Intent to deploy 1/25 SBCT announced; Time 2 assessment (post-garrison duty) conducted FORSCOM identifies 278 th ARNG unit as appropriate National Guard study component
July 04:	Soldiers from 1/25 SBCT not available in May 04 assessed 278 th ARNG assessed (Time 1)
Sep 05:	1/25 SBCT deploys
Nov 05:	3/2 SBCT returns
Dec 05:	278 th ARNG deploys (1 month earlier than originally anticipated) To provide an Active Duty comparison that was deployed contemporaneously with ARNG unit, plans are made to assess 1/25 SBCT upon their return.
Jan 05:	Post-deployment assessment conducted on 3/2 SBCT
Mar 05:	1 st Cavalry returns
May 05:	Post-deployment assessment conducted on 1 st Cavalry and other III Corps units
Aug 05:	Plans made to assess 3/2 SBCT (Time 3) in Sept 05 Katrina displaces New Orleans study team, preventing travel; Sept assessment rescheduled to Dec 05
Oct 05:	Major study equipment retrieved from New Orleans
Dec 05:	Time 3 (follow-up post-deployment assessment conducted on 3/2 SBCT)
Jan 06:	Time 3(initial post-deployment survey) conducted on 1/25 SBCT (unit formerly a non-deployed comparison during the Time 1 to Time 2 interval)
April 06:	Time 2 (post-deployment) assessment of ARNG unit
May 06:	Time 2 (post-deployment) assessment of ARNG unit
Jun 06:	Time 2 (post-deployment) assessment of ARNG unit
Sep 06:	Time 2 (post-deployment) assessment of ARNG unit
Aug 06:	Time 3 assessment completed on 1 st Cavalry

The current timeline now includes Time 2 primary data collection through April 2006, Time 3 primary data collection through October 2007, and Time 3 administrative data collection, data analysis and preparation of final reports extending through January 2008. Therefore the final, approved SOW is as follows:

STUDY TIMETABLE –MODIFIED STATEMENT OF WORK

<u>YEAR 1</u>		
Task 1	Proposal phase and Week 1	Orient project staff to project tasks, training)
Task 2	Months 1-3	Set-up and baseline (Time 1) assessment of Ft. Hood participants
Task 3	Months 4-10	Establish data base; as relevant to Task 2 participants, collection of electronic medical/health care record system databases through data requests, transfer of test data to format readable by statistical software; data entry of data generated by Task 2
Task 4	Months 6-12	Re-assessment of Ft. Hood participants to correspond more closely to their rescheduled deployment date; baseline (Time 1) assessment of Ft. Lewis participants (3/2 Stryker Brigade Combat Team (SBCT); 1/25 Stryker Brigade Combat Team (SBCT);
<u>YEAR 2</u>		
Task 1	Months 13-18	As relevant to Task 4 participants, collection of electronic medical/health care record system databases through data requests, transfer of test data to format readable by statistical software; data entry of data generated by Task 4
Task 2	Months 13-24	Collection of Time 2 data relevant to Ft. Lewis participants
Task 3	Months 13-24	Collection of Time 1 data; deploying National Guard cohort
<u>YEAR 3</u>		
Task 1	Months 25-26	Collection of postdeployment data; Fort Hood participants
Task 2	Months 27-36	Collection of electronic medical/health care record system databases through data requests, transfer of test data to format readable by statistical software; data entry of data generated; data analysis and preparation of reports on all participants included in protocol to date.
Task 3	Months 34-36	Collection of Time 3 data on Fort Lewis participants
<u>YEAR 4</u>		
Task 1	Month 43	Collection of Time 3 (2 nd post-deployment) data on Fort Hood participants
Task 2	Months 39-44	Collection of post-deployment data on National Guard participants
Task 3	Months 36-43	Scientific review and publication of primary T1/T2 Active Duty findings
<u>YEAR 5</u>		
Task 1	Months 52-54	Collection of Time 3 data on National Guard participants
Task 2	Months 54-60	Collection of electronic medical/health care record system databases through data requests, transfer of test data to format readable by statistical software; data entry of data generated relevant to Year 4, Task 3 participants. Data analysis and preparation of final reports.

Progress to date

Progress to date includes accomplishment of all tasks through Year 4. In addition to the elements explicitly listed within the SOW, we have also established an administrative infrastructure, obtained all necessary administrative approvals, and established a Scientific Advisory Council, which meets annually. A manuscript describing the primary neuropsychological Time 1/Time 2 outcomes for Active Duty participants (see Task 3) was published by the *Journal of the American Medical Association* in August, 2006 (Vol. 296, 519-529). (Please see appendix). A manuscript describing rates of baseline posttraumatic stress disorder (PTSD) and the relationship of PTSD symptoms to early life events and unit cohesion is currently in press in the *Journal of Traumatic Stress*.

With the exception of Time 3 rater-scored Visual Reproduction data, all data collected to date have been entered and subjected to intensive data quality checks. Data management has required extensive effort because of the anomalies regarding participant classification as “deployed” or “non-deployed” and the addition of a second baseline for the 1st Cavalry unit. However, a comprehensive and synthesized data base had been established. Primary outcomes for Time 1 to Time 2 have been conducted for the Active Duty component. We are currently in the process of completing analyses relevant to secondary objectives (PTSD outcomes) for Time 1 to Time 2 Active Duty comparisons.

Time 1 enrollment totaled 1595 participants. Time 2 assessments have been conducted on all participating units with the exception of a small Air National Guard unit and include a total of 1049 participants to date. Longitudinal retention for Active Duty Soldiers has been approximately 76.7%. Among those who were not retained for Time 2 assessment, the primary reasons for loss to follow-up have been changes in military unit assignments (14%) and separation from service (46.1%). Longitudinal retention of National Guard Soldiers has been lower (61%) and reflects re-organization within the 278th and, more often, separation from the National Guard.

Time 3 (1-year follow-up) in-person assessments were conducted on a much smaller subgroup of active duty soldiers (n=186) who remained in the military with their originating units. In addition, we have completed Time 2 (initial post-deployment) assessment of a brigade that had been assessed previously before and after a period of garrison duty but subsequently deployed.

Unit membership for the original Time 1/Time 2 Active Duty deploying units has been submitted to the US Army Center for Health Promotion and Preventive Medicine to facilitate obtaining appropriate linked environmental data. We are currently summarizing such information to submit for the National Guard units and the active duty unit that deployed between Time 2 and Time 3.

Findings to date

1. Primary outcomes: Neuropsychological functioning

Findings from multi-level analyses that take into account battalion-level unit membership and demographic covariates indicate that deployment was associated with disadvantages to memory functioning (as measured by a non-computerized word list learning task, WMSIII Verbal Paired Associates I sum and a visual reproduction task, WMS Visual Reproductions delay and savings ratio) and attention (as measured by number of non-response errors on a computerized simple continuous performance task, NES3 CPT), but advantages to reaction time efficiency (ANAM Simple Reaction Time). All other tasks of cognitive efficiency (ANAM) were unaffected. Additionally, deployment was associated with adverse changes in emotional functioning, including symptoms associated with posttraumatic stress disorder (PTSD) and state affect, including POMS Confusion and Tension scores. In contrast, deployment was not associated with changes in measures of state (POMS) depression, vigor, anger, or fatigue, or measures of functional health (SFv12 and MOS Cognitive) including self-perceptions of cognitive, emotional, and physical functional impact.

These findings have been published in the *Journal of the American Medical Association* (see attachment).

2. Secondary outcomes: PTSD and functioning

a. We examined relationships among stressful life events, perceived unit cohesion, and PTSD symptom severity at Time 1 across the entire NDHS cohort. We found that a sizable subset of military personnel (10%) reported significant pre-deployment, stress-related symptoms, as measured by the PCL, a 17-item DSM-based self-report survey, and using the criteria established by Hoge et al. (2004). Regression analyses revealed that life experiences ($\beta = 1.20$, $p < .001$) and unit cohesion ($\beta = -0.35$, $p < .001$) independently predicted PTSD symptoms at baseline, together predicting 22% of the variance, even after taking into account demographics and duty status.

A scientific manuscript describing these findings is currently in press in the *Journal of Traumatic Stress*.

b. We have completed preliminary analyses examining PTSD symptoms among active duty soldiers. A mixed model MANOVA (deployment x time) revealed that deployment status interacted with time of assessment for PCL total symptom ($p < .001$), re-experiencing ($p < .001$), and arousal ($p < .001$) scores. As shown in the following table, follow-up comparisons suggested that deployment was associated with an increase in PTSD symptom severity on the PCL among deployed soldiers that appears to be driven by specific increases in re-experiencing and arousal symptom clusters. The increase in arousal symptoms is especially relevant to our primary neuropsychological outcomes, which were interpreted to be consistent with an arousal-based stress response.

Paired t-tests (Time 1 v. Time 2) in each deployment group with PTSD Checklist (PCL) summary and symptom cluster scores as outcome variables

PCL index	Deployed (n = 674)		Non-deployed (n = 315)	
	Time 1	Time 2	Time 1	Time 2
Summary score	29.15 (12.35)	32.50 (13.20) ***	29.62 (13.09)	29.38 (13.04)
Re-experiencing	7.84 (3.94)	9.38 (4.36) ***	8.25 (4.23)	8.20 (4.36)
Avoidance/numbing	11.78 (5.54)	12.18 (5.49)	11.90 (5.84)	11.88 (5.80)
Arousal	9.51 (4.30)	10.99 (4.85) ***	9.45 (4.16)	9.30 (4.10)

Mean (sd), and ***p < 0.001 for paired t-tests (Time 1 v. 2 within each deployment category)

c. Preliminary assessment of available NDHS data suggest that self-reported day-to-day functioning related to *cognitive and somatic health problems* declined among both deployed and non-deployed active duty participants, but that deployment status did not interact significantly with time. As shown in the following table, there were no significant changes from Time 1 to Time 2 in self-reported *mental health-related functioning* among either deployed or non-deployed participants. These findings highlight the significance of neuropsychological and health-related changes on day-to-day functioning, but raise the question that factors other than deployment status alone might influence such changes.

Paired t-tests (Time 1 v. 2) within each deployment group with functional impact scores as outcome variables

	Deployed (n = 674)		Non-deployed (n = 315)	
	Time 1	Time 2	Time 1	Time 2
Physical Component, SF12v	51.85 (7.00)	50.61 (7.46) ***	51.82 (7.39)	50.49 (8.53) **
Mental Component, SF12v	49.62 (10.78)	49.77 (10.57)	48.90 (11.12)	48.26 (11.77)
Cognitive functioning	78.02 (20.13)	73.51 (21.10) ***	77.47 (19.77)	74.70 (22.26) **

Mean (sd); **p < 0.01; ***p < 0.001, paired t-tests (Time 1 v. 2) within each deployment group

d. We also queried for health symptoms among deployed soldiers, beginning at their initial postdeployment assessment. The following table depicts the rates at which active duty deployed participants reported frequent health symptoms at postdeployment. Over 10% of the deployed participants reported gastrointestinal symptoms, headaches, muscular discomfort, and joint pains that occurred several times per week; and over 25% reported frequent fatigue and backaches. These health symptoms have been shown to be associated with military stress exposures.^{8,9}

Percentage of active duty soldiers (n=654) at postdeployment assessment reporting health symptoms occurring several times per week or more

Backaches	29%
Fatigue or overtired, lack of energy	25%
Joint pains	23%
Muscle aches or stiffness	21%
Headaches	17%
Stomach cramps or excessive gas	12%
Numbness in arms/legs	8%
Dizziness or feeling light-headed	8%
Racing heart	8%
Nausea and/or upset stomach	7%
Skin rashes, eczema, skin allergies	6%
Diarrhea	6%
Difficulty breathing or shortness of breath	5%
Rapid breathing	5%
Common cold or flu	5%
Chest pain	4%
Irregular beats or “heart flutters”	3%

The next steps in the analyses will be: (1) examination of exposures that predict PTSD (2) examination of the longitudinal associations among neuropsychological functioning, traumatic brain injury, and PTSD; (3) examination of the duty status, comparing the deployed Army National Guard Unit outcomes to those of an Active Duty participants matched as closely as possible for demographics, MOS, and deployment stress exposures; (4) examination of the association between PTSD development and standardized test taking ability among deployed active duty soldiers.

KEY RESEARCH ACCOMPLISHMENTS

Brailley, K., Vasterling, J. J., Proctor, S. P., Constans, J. I., & Friedman, M. J. (in press). PTSD symptoms, life events, and unit cohesion in U.S. soldiers: Baseline findings from the Neurocognition Deployment Health Study. *Journal of Traumatic Stress*.

Vasterling, J.J., Proctor, S. P., Amoroso, P., Kane, R., Heeren, T., & White, R.F. (2006). Neuropsychological Outcomes of Army Personnel Following Deployment to the Iraq War: A Prospective Examination. *Journal of the American Medical Association*, 296, 519-529.

Vasterling, J.J., Proctor, S. P., Amoroso, P., Kane, R., Gackstetter, G., Ryan, M.A.K., & Friedman, M.J. (2006). The Neurocognition Deployment Health Study: A prospective cohort study of Army soldiers. *Military Medicine*, 171, 253-260.

Rutkowski, L., Vasterling, J.V., & Proctor, S.P. (accepted). *PTSD and standardized test performance: An example of IRT with covariates*. Paper to be presented at the 2007 annual American Educational Research Association Annual meeting. Chicago, IL.

Vogt, D., Proctor, S.P., Vasterling, J. J., King, D., & King, L. (November, 2006). *Deployment risk and resilience factors and mental health: Findings from the NDHS*. Paper presented at the 22nd Annual Meeting for the International Society for Traumatic Stress, Los Angeles, CA.

Proctor, S. P., & Vasterling, J. J. (November, 2006). *Comparison of active duty and national guard soldiers on pre-deployment factors: Findings from the NDHS*. Paper presented at the 22nd Annual Meeting for the International Society for Traumatic Stress, Los Angeles, CA.

Vasterling, J. J. & Proctor, S. P. (November, 2006). *Prospective analysis of memory functioning and PTSD in Army soldiers: Findings from the NDHS*. Paper presented at the 22nd Annual Meeting for the International Society for Traumatic Stress, Los Angeles, CA.

Vasterling, J. J. (August, 2006). *The Neuropsychology of PTSD: Longitudinal Findings from the Neurocognition Deployment Health Study (NDHS)*. Division 40 Invited Presentation to the American Psychological Association Convention 2006, New Orleans, LA.

Rutkowski, L., Proctor, S.P., & Vasterling, J.J. (November, 2006). *Explanatory item response theory in trauma research*. Paper presented at the Annual Conference on Innovations in Trauma Research Methods meeting. Hollywood, CA.

Vasterling, J. J. (June, 2005). *Examining the Neuropsychological Outcomes of Iraq Deployment: A Model of Effective DoD/VA Research Collaboration*. Invited presentation at the National Mental Illness Research, Education, and Clinical Center 2005 Conference, New Orleans, LA.

Proctor, S. P., & Vasterling, J. J. (May, 2004). *Update: From the Gulf War to Operation Iraqi Freedom*. Invited presentation for the USARIEM Environmental Medicine Course 2004, Natick, MA.

Vasterling, J. J. (July, 2004). *Prospective Assessment of Psychological and Neuropsychological Functioning in Iraq-deployed Army Troops: A Preliminary Cross-sectional Report*. Invited paper presentation at the VISN 16 MIRECC/National Center for PTSD Summit Meeting, Resilience and Treating Early PTSD, New Orleans, LA.

Vasterling, J.J., Proctor, S. P., & Kane, R. (October, 2003). *Prospective Assessment of Gulf-deploying and Gulf-nondeploying troops*. Paper presented at the 19th Annual Meeting for the International Society for Traumatic Stress, Chicago, IL.

Vasterling, J. J. & Proctor, S. P. (May, 2003). *Prospective Assessment of Iraq-deploying and Non-deploying Troops: An Interdepartmental Effort*. Invited presentation to the Research Subcommittee of VA/DoD Deployment Health Work Group, Washington, D.C.

Vasterling, J. J. & Proctor, S. P. (June, 2003). *Prospective Assessment of Iraq-deployed Troops*. Invited presentation to the Research Advisory Council on Gulf War Veterans Illnesses, Washington, D.C.

REPORTABLE OUTCOMES: THIS REPORTING PERIOD

- please see attached *JAMA* publication
- manuscript in press, *Journal of Traumatic Stress*
- information from the application of the ANAM in this study has been used to inform modification and quality assurance assessment of the ANAM
- information from the application of the Deployment Risk and Resilience Inventory has been used as the basis of a VA-funded grant to examine its psychometric characteristics and refine item content to optimize use with OIF/OEF populations
- planning phase for a VA multi-site cooperative study approved and funded; planning phase in process

CONCLUSIONS

Process Conclusions

This study has established an effective model of inter-departmental collaboration between VA and DoD. This is a critical accomplishment relevant especially to longitudinal research addressing outcomes throughout both military and post-military life periods.

In addition, the work accomplished has provided a model of how neurobehavioral assessments could potentially be incorporated into more regular surveillance with the military. With memory and other cognitive complaints factoring high among war-zone returnees and being of high relevance to occupational functioning and cognitive readiness, the establishment of neurobehavioral surveillance methodology is significant to force health protection efforts. The methods used in this study are non-invasive and could potentially be implemented in a cost-effective manner on a broader scale.

Scientific Conclusions

Findings to date suggest that there are objective changes in neuropsychological functioning associated with deployment. While at least one is at face value positive (efficiency in simple reaction time), others are negative (less proficient attentional and memory performances, increased emotional symptoms). Taken together, findings raise the question of a biological stress response, involving neurotransmitter/hormonal systems relevant to the neurobehavioral findings listed above. The design elements of a baseline assessment and of a non-deploying comparison sample well-matched to the deploying sample on key demographic and military characteristics suggest that these findings cannot be attributed solely to pre-existing conditions or simply to the passage of time.

The next critical steps will be to examine the secondary outcome, PTSD and the impact of specific risk and resilience factors on the outcomes to determine which individual and deployment-related factors may be serving as critical determinants. For example, our findings suggest that unit cohesion, a modifiable factor, can decrease risk of emotional distress following exposure to stressful life events. Given that we have found an increase in PTSD symptoms over the deployment period, identification of modifiable risk factors for negative emotional outcomes will continue to be of considerable importance in developing preventive health strategies.

The ongoing work will also allow examination of whether these findings are stable over time, if longer-term outcomes can be predicted by early neurobehavioral markers, whether duty status (regular Active Duty versus Guard/Reserve) influences outcomes, and the impact of adverse outcomes on occupational functioning and service utilization with DoD and VA medical care facilities. Finally, our screening for head injury over the deployment period will allow exploration of associations between neurocognitive functioning, traumatic brain injury, and emotional functioning.

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Appendix

ORIGINAL CONTRIBUTION

Neuropsychological Outcomes of Army Personnel Following Deployment to the Iraq War

Jennifer J. Vasterling, PhD

Susan P. Proctor, DSc

Paul Amoroso, MD, MPH

Robert Kane, PhD

Timothy Heeren, PhD

Roberta F. White, PhD

SINCE EARLY 2003, SIGNIFICANT numbers of military personnel have deployed in support of Operation Iraqi Freedom (OIF). Although contemporary battlefield measures¹ have improved war-zone survival, success in preventing fatalities has not eliminated adverse physical or mental^{2,3} health consequences. One major war-related health risk is brain dysfunction.

Brain dysfunction is often indicated by neuropsychological (ie, cognitive and emotional) impairment. In past military conflicts, cognitive impairment figured prominently among veteran health complaints, ranking fourth among 1991 Gulf War veterans in government health registries.⁴ Because of its potential negative impact on occupational and psychosocial functioning⁵⁻⁷ in a predominantly young population, war-related neuropsychological impairment has significant public health implications.

Yet, the consequences of war-zone deployment on neuropsychological health remain poorly understood. Knowledge gaps stem largely from a lack of baseline (predeployment) health information, reliance in large studies on

Context The effects of war-zone deployment on neuropsychological health remain poorly understood. Neuropsychological performance deficits serve as sensitive measures of neural dysfunction and are often associated with psychosocial and occupational problems. Previous studies have not conducted objective neuropsychological assessments both before and after a major war-zone deployment.

Objective To examine objective neuropsychological outcomes of Iraq War deployment in a large military cohort.

Design, Setting, and Participants The Neurocognition Deployment Health Study, a prospective, cohort-controlled study conducted at military installations. This report centers on 961 male and female active-duty Army soldiers drawn from the larger cohort. Deploying Army soldiers (n=654) were examined prior to deployment to Iraq (April-December 2003) and shortly after return (within a mean of 73 days [median, 75 days]; January-May 2005) from Iraq deployment. A comparison group of soldiers (n=307) similar in military characteristics but not deploying overseas during the study was assessed in sessions timed to be as close as possible to the assessment of deployers. Military unit sampling procedures facilitated representation of combat, combat support, and combat service support functions among both deployers and nondeployers.

Main Outcome Measures Individually administered, performance-based neuropsychological tasks. Estimates (β ; the unstandardized parameter estimate) for the absolute differences in adjusted mean outcome scores between deployed and nondeployed groups were determined using generalized estimating equations.

Results Multiple linear regression analyses adjusted for battalion membership revealed that Iraq deployment, compared with nondeployment, was associated with neuropsychological compromise on tasks of sustained attention ($\beta=0.11$; $P<.001$), verbal learning ($\beta=-1.51$; $P=.003$), and visual-spatial memory ($\beta=-3.82$; $P<.001$). Iraq deployment was also associated with increased negative state affect on measures of confusion ($\beta=1.40$; $P<.001$) and tension ($\beta=1.24$; $P<.001$). In contrast, deployment was associated with improved simple reaction time ($\beta=4.30$; $P=.003$). Deployment effects remained statistically significant after taking into account deployment-related head injury and stress and depression symptoms.

Conclusions Deployment to Iraq is associated with increased risk of neuropsychological compromise. Findings point to the need to investigate further the impact of deployment on neural functioning. Public health implications include consideration of neuropsychological compromise in health prevention and postdeployment clinical and occupational management.

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For editorial comment see p 574.

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