Historical Cohort Study of Posttraumatic Stress Disorder (PTSD) and the Risk of Motor Vehicle Crash Hospitalization among Recent Veterans Enrolled in Veterans Administration Healthcare

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Fall 2013

A THESIS

Presented to the Department of Public Health & Preventive Medicine

and the Oregon Health & Science University School of Medicine

in partial fulfillment of the requirement for the degree of

Master of Public Health

Department of Public Health and Preventive Medicine

School of Medicine

Oregon Health & Science University

CERTIFICATE OF APPROVAL

This is to certify that the Master's thesis of

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LIST OF ABBREVIATIONS

CI	95% Confidence Intervals
DAG	Directed Acyclic Graph
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders-IV
DSM-V	Diagnostic and Statistical Manual of Mental Disorders-V
E-Code	External Cause of Injury Code(s)
ICD-9-CM	International Classification of Diseases-Ninth Revision-Clinical Modification
IED	Improvised Explosive Device
MVC	Motor Vehicle Crash
NPCD	National Patient Care Database (Veterans Affairs)
OEF	Operation Enduring Freedom (Afghanistan War, October 2001 to Present)
OIF	Operation Iraqi Freedom (Iraq War, March 2003 to August 2010)
OND	Operation New Dawn (Iraq War, September 2010 to December 2011)
OTH	Other Than Honorable Discharge
PCL	PTSD Checklist
PDHA	Post-Deployment Health Assessment
PDHRA	Post-Deployment Health Reassessment
PTSD	Posttraumatic Stress Disorder
RR	Relative Risk
TBI	Traumatic Brain Injury
U.S.	United States
USAA	United Services Automobile Association
VA	United States Department of Veterans Affairs
VHA	Veterans Health Administration

ACKNOWLEDGEMENTS

I would like to thank Dr. Kathleen Carlson for giving me the opportunity to study injury epidemiology under her guidance. She spent countless hours of working one-on-one with me to guide me through this complicated process that I was completely new to. This thesis (and internship and professional development experiences including presentations at APHA, OPHA and the OHSU Research Week) would not have been possible without her.

I would like to thank Dr. William Lambert for giving me the opportunity to fulfill my dream of studying epidemiology that began in 10th grade. He is an excellent and insightful mentor. He was open to my ideas as a student representative, which made it a great experience to serve my fellow students. He is the cornerstone of the Public Health and Preventive Medicine Department, and my peers and I are very grateful to him.

I would like to thank Dr. Dawn Peters for serving on my committee, for raising important, intelligent questions at every committee and private meeting, for contributing her understanding of biostatistics and SAS, and for being very positive in every encounter.

I would like to thank Dr. Maya O'Neil for serving on my committee, for contributing key knowledge about biostatistics and clinical aspects of Veterans' health. She helped me to understand more about the VA data, implications of this study and she was always supportive and positive.

I would like to thank my loving husband, Nick. He has been my rock over the last nine years, particularly these three years of graduate school. He made me believe I would and could make it.

CHAPTER I: ABSTRACT

Combat Veterans have an increased risk of motor vehicle crash (MVC)-related death compared to non-combat Veterans. We examined whether posttraumatic stress disorder (PTSD) was associated with hospitalizations for MVC-related injuries in Iraq and Afghanistan War Veterans who use Veterans Health Administration (VHA) healthcare. We conducted a historical cohort study using VHA medical records for 119,343 Veterans who enrolled in VHA healthcare within a year of deployment and who used VA healthcare services consistently for five years. We used univariate and multivariate generalized linear models to estimate the five-year relative risk (RR) of MVC-related hospitalization among Veterans who were diagnosed with PTSD within the first year post-deployment versus those who were not. PTSD exposure was defined as one or more inpatient stays or two or more outpatient encounters where the Veteran was given a code for PTSD (ICD-9 code: 309.81). Multivariate models adjusted for age, gender, race/ethnicity, education, marital status, military branch, military component, number of deployments, distance to the nearest VA, and service connection status. Three hundred seventy-three of 119,343 Veterans were hospitalized for MVC-related injuries within five years of deployment; typically they were male (87%) and 18-24 years old (33%). Compared to Veterans not given PTSD diagnoses, those diagnosed with PTSD were 40% more likely to be hospitalized for MVC-related injuries (RR=1.4; 95% CI=1.1 to 1.7). However, after adjustment for potential confounders, Veterans diagnosed with PTSD had no greater risk than those without a diagnosis (RR=1.0; 95% CI=0.8 to 1.2). Therefore, PTSD appears to be an indicator rather than a causal factor for increased risk of MVC among post-deployment Veterans. The findings of our historical cohort study

confirm that combat Veterans with a PTSD diagnosis within a year of deployment have an increased risk of hospitalization due to motor vehicle crash (MVC)-related injury within five years of deployment compared to Veterans not given a PTSD diagnosis. Additional research is needed to disentangle these complex relationships, and to explore risk factors for all MVCs among all Veterans.

CHAPTER 1: BACKGROUND

There is a history of higher incidence of fatal injury, particularly motor vehicle crash (MVC) injury, among Veterans with combat experience compared to Veterans who have deployed but to non-combat zones and/or non-deployed Veterans (1-3). MVCs were one of the major causes of injury-related death among Veterans of the Vietnam War and the Gulf War (4,5). Studies in Australia have shown similar trends (6). Research suggests most of the excess risk of death from injury was isolated to within approximately five years post-deployment (1). Thus, there appears to be a short window of opportunity when interventions could be implemented to save lives and prevent suffering due to post-deployment injuries in current and future cohorts of combat Veterans.

In 1987, the Centers for Disease Control and Prevention published the Vietnam Experience Study on Postservice Mortality. The study revealed that, for the first five years post-deployment, Vietnam Veterans had a significantly higher relative risk (RR) for MVC mortality (RR=1.9; 95% CI=1.2 to 3.2) compared to non-Vietnam Veterans of the US Army who served in the United States, Germany or Korea after 1965. However, starting at six years post-deployment, the RR of MVC mortality was no longer significantly higher (RR=1.2; 95% CI=0.7 to 1.9) for the Vietnam Veterans compared to Veterans who served elsewhere (2). In 2001, Kang and Bullman investigated a seven year post-deployment period of increased risk of MVC mortality among Persian Gulf War Veterans compared to non-Gulf War Veterans who were on active duty, in the Reserves or in the National Guard during the same years. The RR of MVC death declined over the

seven-year follow-up period from 1.3 (95% CI=1.1 to 1.5) to 1.0 (95% CI=0.8 to 1.2), with no significantly increased risk after six years post-combat (3).

In 2001, Bell et al. proposed a model identifying possible reasons for the increased risk of fatal injury among combat Veterans. This model depicted five pathways from Gulf War deployment to excess risk of injury events and/or poorer outcomes after injury events for those Veterans compared to non-deployed Gulf War-era Veterans. The five proposed pathways were "psychological distress (e.g., PTSD, depression)", "behavioral/coping (e.g., alcohol or drug use, reckless behavior)", "disease symptoms (e.g., dizziness, headaches, unrefreshing sleep)", "excess risk for injury events and/or subsequent poorer outcomes", and "pre-deployment baseline characteristics (e.g., risk taking behaviors, occupational exposures)" (7).

Publications in newspapers and the popular media have touched on the topic of dangerous driving among combat Veterans. In a notable *New York Times* article in January 2012, called "Back from War, Fear and Danger Fill Driver's Seat," James Dao cited research showing Veterans with more severe PTSD to be more aggressive drivers, citing experts as saying that combat Veterans with or without PTSD may be aggressive or defensive drivers (8). Similarly, a *Reuters* article from April, 2012 reported that a United Services Automobile Association (USAA; an insurer for armed forces and their families) study found deployed Veterans were in 13% more at-fault MVCs in the six months following overseas deployment compared to the six months prior to deployment, based on their own records (9). The USAA study attributed the elevated rates to adaptive driving skills that Veterans developed in Iraq and Afghanistan and continued in the United States (10).

The objectives of this study were to use Veterans Health Administration (VHA) medical records to conduct a historical cohort study examining potential associations between PTSD and MVC-related hospitalizations among Veterans of Operations Enduring Freedom, Iraqi Freedom, and New Dawn (OEF/OIF/OND) within the first five years after deployment. We hypothesized that there would be an increased relative risk of hospitalizations due to MVC-related injuries among Veterans in our study population who were diagnosed with PTSD within the first year post-deployment versus those who were not.

CHAPTER 2: MANUSCRIPT

BACKGROUND

Veterans of past wars have been shown to have an increased risk of post-deployment fatal injury relative to contemporary Veterans who did not serve in conflict areas.[1] While not yet examined, it is likely that Veterans of the wars in Iraq and Afghanistan would have a similarly increased risk of fatal injury. While non-fatal injury is more common than fatal injury, the risk of post-deployment non-fatal injury among combat Veterans of any era is not well established.[2, 3]

Research since the 1980s has shown that a large proportion of the post-deployment injury-related deaths of Veterans were attributable to motor vehicle crashes (MVC). In their systematic review, Knapik et al. (2009) concluded that after the Vietnam and Gulf War periods, mortality from motor vehicle-related injuries was higher among Veterans deployed to conflict zones compared with Veterans of the same era who did not experience a deployment to a conflict zone.[1] Additional work has shown that this increased risk of MVC fatalities is observable during a window of approximately five years post-deployment, after which the risk drops to the same levels as the risk for Veterans who served in non-conflict settings.[4] While no empirical studies have examined the risk of MVC-related injuries among Iraq and Afghanistan combat Veterans compared to non-combat Veterans specifically, the United Services Automobile Association (USAA), an insurer for armed forces personnel and their families, recently reported that deployed Veterans were in 13% more at-fault MVCs in the six months following overseas deployment compared to the six months prior to deployment.[5]

Bell and colleagues (2001), proposed posttraumatic stress disorder (PTSD) as one potential cause of the increased risk of fatal injury among combat Veterans relative to non-combat Veterans.[6] PTSD is an anxiety disorder which can develop after a person directly experiences or witnesses a traumatic event involving life-threat, serious injury, or sexual violation,[7] and is associated with increased risk of death. [8] Studies have reported PTSD prevalence estimates ranging from 2.2% to 17.3%.[9] Considering that more than 2.5 million United States servicemen and women have served in Iraq and Afghanistan since 2001,[10] a better understanding of the effects of PTSD on MVC-related injuries in this population has the potential to save lives and preserve a quality of life for Veterans and their families. The purpose of this study was to use Veterans Health Administration (VHA) medical records to examine potential associations between PTSD and MVC-related hospitalizations among Veterans of Operations Enduring Freedom, Iraqi Freedom, and New Dawn (OEF/OIF/OND) within the first five years after deployment.

METHODS

Overview and Study Population

We conducted a historical cohort study using medical records data from the national VHA system for OEF/OIF/OND Veterans. Because past research has shown the risk of fatal MVC-related injuries to be heightened in the first five years post-deployment,[4] we restricted our analyses to Veterans who enrolled in VA healthcare within the first year post-deployment and followed them for five years from deployment, regardless of when during the first year they enrolled. To focus on those Veterans most likely to be hospitalized in the VA after a MVC, we also restricted our sample to "frequent users" of

VA services, defined as those who had at least five visits total, with at least one visit in the first year and at least one visit in either the fourth or fifth year. We also excluded Veterans who died before or during the five-year post-deployment period and Veterans who had not received any medical diagnoses in the five year period, resulting in a sample of 119,343 Veterans for analysis. The Institutional Review Boards of the Portland VA Medical Center and Oregon Health & Science University approved this study.

Study Design & Data Sources

We identified Veterans using the OEF/OIF/OND Roster, which is based on military records and includes demographic information and limited deployment information for all Veterans who served in and around Iraq and Afghanistan from 2001 through 2011. These data were merged with data from the VHA National Patient Care Database (NPCD) to identify outpatient encounters and inpatient stays and the associated International Classification of Diseases-Ninth Revision-Clinical Modification (ICD-9-CM) diagnosis codes and the external cause of injury codes (e-codes). Data for non-VHA inpatient and outpatient healthcare were not available for our analysis.

Measures

Dependent Variable

Hospitalizations for MVCs anytime within the first five years post-deployment were identified using inpatient diagnosis codes for injury that were assigned in conjunction with e-codes related to a MVC (e-codes 810-825). We focused on inpatient records because nearly all injury-related stays were assigned e-codes. It was not possible to examine outpatient encounters related to MVC, as low proportions of outpatient encounters related to injuries were assigned e-codes.

Independent Variable

Consistent with approaches used by previous researchers,[11] [12] we classified Veterans as having PTSD if they had two or more outpatient encounters or one or more inpatient stays within the first year post-deployment in which an ICD-9-CM code for PTSD (309.81) was assigned.

Covariates

Using OEF/OIF/OND Roster data, we identified additional available variables, including *gender* (female or male), *race/ethnicity* (white or non-white), *education* (high school diploma or less, some college, or bachelors or higher), *number of deployments* (one or more), *branch of service* (Air Force, Army, Coast Guard/Navy or Marines), and military *component* (active duty or reserve/guard). Measures for the following variables were taken at the end of deployment: *age* (18-24 years, 25-29 years, 30-39 years, 40 or more years old) and *marital status* (never married, married or divorced/separated/widowed). *Miles to VA* was computed as miles from the Veteran's home zip code to the nearest VA facility at the time of his or her latest visit to the VA, regardless of which facility he or she visited. The VA assigns disability ratings to Veterans proportionate to levels of disability related to their military service;[13] VA "service connection" is assigned as percentage values that increase at 10% intervals from zero to 100%. We categorized *service connection status* as none, 0-40%, or ≥50%. Veterans with no service connection did not apply, or are classified as having a service connected disability, but because of the nature or severity of the disability, do not receive compensation.

Analyses

We conducted descriptive analyses of the demographic and deployment characteristics of Veterans included in the cohort. We used univariate and multivariate generalized linear models to estimate the five-year relative risk (RR) and 95% confidence intervals (CI) of hospitalization due to MVC-related injury among Veterans who were given a diagnosis code for PTSD during two or more outpatient encounters or one or more inpatient stays within the first year post-deployment versus those who were not. Covariates were selected *a priori* based on a directed acyclic graph (DAG; see Appendix A).[14] The DAG illustrates our analytic framework, showing the hypothesized relationships between demographic, military service, and VA access variables, with those of the VA health services, including: diagnoses of other mental health conditions, chronic pain, substance use disorders, sleep disorders/deprivation, and traumatic brain injury (TBI). In the context of this study with health systems data, we hypothesized that the diagnoses in the DAG are associated; therefore we did not adjust for these covariates in our final model. We considered service connection status to occur earlier in time than a VHA diagnosis of PTSD. Based on our DAG, we adjusted for age, gender, race/ethnicity, branch, component, number of deployments, education, marital status, distance to the nearest VA, and service connection status. Statistical analyses utilized generalized linear modeling methods and were conducted with SAS System 9.3 [proc genmod, log link function].[15]

RESULTS

Among our sample of 119,343 Veterans of OEF/OIF/OND who frequently utilized VHA services in the 5-year period post-deployment, 23.1% (27,534) received PTSD diagnoses during at least two VA outpatient encounters or at least one VA inpatient VA stay, and 0.31% (373) were hospitalized for MVC-related injuries at a VA facility. Of those hospitalized for MVC-related injuries, 29.8% (111) were diagnosed with PTSD. Veterans hospitalized at least once for MVC-related injuries were found to differ on certain characteristics from those who were not hospitalized for MVC-related injuries: they tended to be younger, male, and never married; to have no more education than a high school diploma; served as an Active Duty member of the military; and have VA service connection of 50% or greater (Table 1).

Table 2 displays the results of analyses examining risk of MVC-related hospitalization relative to PTSD diagnosis. The univariate risk of a hospitalization for MVC-related injuries was 40% higher among Veterans with PTSD diagnoses compared to those who were not diagnosed with PTSD (RR=1.4; 95% CI=1.1 to 1.7). However, this excess risk was no longer present in the multivariate generalized linear model after statistical adjustment for age, gender, race/ethnicity, education, marital status, number of deployments, military branch, component, miles from the Veteran's home to the nearest VA, and service connection status (RR=1.0; 95% CI=0.8 to 1.2).

DISCUSSION

Past research shows that combat Veterans are at higher risk of dying in MVCs during the first years post-deployment than Veterans that did not deploy or those who deployed but to non-combat zones.[1, 4] Some authors have suggested that PTSD is associated with this increased risk.[6] Results of our study showed that, during the first five years post-deployment, there was a moderately higher risk of a hospitalization for MVC-related injuries among Veterans with PTSD diagnoses compared to those who were not diagnosed with PTSD. However, this excess risk was no longer present after statistical adjustment for potential confounders, including age, gender, race/ethnicity, education, marital status, number of deployments, military branch, component, miles from the Veteran's home to the nearest VA, and service connection status.

Our findings reveal a burden of hospitalizations due to injuries from MVCs among Veterans diagnosed with PTSD, but suggest that factors other than PTSD, including demographic and deployment characteristics, are driving the observed increase in risk. Veterans hospitalized at least once for MVC-related injuries were found to differ on certain characteristics from those who were not hospitalized for MVC-related injuries: they tended to be younger, male, and never married; to have no more education than a high school diploma; to have served as an Active Duty member of the military; and to have VA service connection of 50% or greater. In the general population, being male, young, driving a motorcycle, speeding, alcohol-impairment, and not using seatbelts have been shown to be risk factors for MVC-crash related fatal and non-fatal injuries;[16] therefore these are also likely to be risk factors in this population. In the current study, we were able to control for gender and age, along with other potential confounders; however,

prevalence of risky behaviors such as driving motorcycles, speeding, or drinking and driving were unavailable.

Previous authors have established that Veterans face health risks during the resumption of their civilian lives, including motor vehicle crashes and related injury and mortality.[4, 6, 17] Bell et al.'s publication (2001) urged researchers to search for the etiology of this elevated risk for morbidity and mortality due to post-deployment injury.[6] This study posited psychological distress, e.g. PTSD, as a risk factor for MVC-injury and mortality. Therefore we used VHA data to evaluate the potential association between diagnosed PTSD and MVC-related hospitalizations. Consistent with previous researchers' hypotheses and findings, we observed an increased risk of hospitalization for MVC-related injuries among Veterans who have received services for PTSD. We did not attempt to differentiate between PTSD and other sources of psychological distress due to high correlation between mental health diagnoses. Future work should explore whether psychological conditions other than PTSD have effects on risk of MVC among post-deployment Veterans.

In addition to the "psychological distress" pathway proposed by Bell et al., we were able to adjust for some "baseline characteristics" in our multivariate model. In our DAG, we considered certain pre-deployment factors including age, gender, race, education, and marital status. While we were not able to capture risk-taking behaviors, genetics or pre-deployment traumatic experiences, the baseline characteristics in our study may be associated with those behaviors and with a pre-disposition to excess injury risk. In the words of Bell et al., "It is plausible, however, that the same factors that make a soldier a likely candidate for deployment may also be associated with greater risk of

injury independent of war."[6] Our findings were consistent with those of Carlson et al. in that mental health disorders, specifically PTSD, appear to be an important indicator of injury risk.[17] Future research should further consider anger control problems, other mental or physical health disorders, and driving behavior characteristics.

Strengths and Limitations

One of the strengths of a historical cohort study design is the ability to assess temporality. We decided *a priori* that this study would analyze PTSD status within year one post-deployment and MVC hospitalization status within years one through five post-deployment; hence we anticipated that some of the MVC-related VA stays would occur prior to some VA encounters or stays in which Veterans were given their first PTSD diagnosis. If the Veteran experienced a MVC in the first year post-deployment, it is possible that a subsequent diagnosis of PTSD was caused by the MVC itself rather than PTSD having served as a risk factor for the MVC. However, it is also reasonable to assume that any first-year PTSD diagnoses given subsequent to a MVC could be indicative of combat-related PTSD, with symptoms being further aggravated by the MVC or undiagnosed until after the MVC. Simply put, even if the first PTSD diagnosis was made after a first-year MVC hospitalization, it is possible that the Veteran had preexisting PTSD at the time of the hospitalization. We acknowledge that this design does not strictly identify temporality of PTSD diagnoses and MVC hospitalizations, but the study design does make a reasonable assessment of temporality and MVC risk relative to PTSD status.

Additional limitations of concern for this study include potential selection bias and misclassification bias. First, we acknowledge that VA health services data do not

represent all Veteran health care service utilization for mental health or trauma care, which may lead to selection bias. This concern does not affect the internal validity of our study, but it limits how representative the results are to Veterans who do not use VHA services regularly within their first five years post-deployment. Moreover, our study only examined the risk of MVC-related injuries that resulted in a hospitalization. Risk factors for fatal MVCs or those that do not result in hospitalizations may be distinct than those that do. We did not capture former military men and women who served but were administratively separated from the military with an Other Than Honorable (OTH) discharge and therefore were not qualified for Veteran status. Just over half of Veterans who do qualify for VA healthcare enroll and seek care at the VA.[18]

An additional limitation to consider is potential misclassification of the exposure and outcome, which is relevant for internal validity in the study. Concerning misclassification of PTSD status, it is of note that VA healthcare providers code outpatient diagnoses whereas professional coders code inpatient diagnoses, therefore it is reasonable to assume that inpatient diagnoses may be coded more accurately than outpatient diagnoses (and is why our operational definition of PTSD required more than one outpatient PTSD diagnosis while only requiring one inpatient diagnosis). Additionally, there is known stigma around mental health problems. Therefore, exposure misclassification may have occurred in the case of 'frequent user' Veterans who postponed or avoided treatment for PTSD, and the resulting bias may be differential or non-differential by outcome. It is plausible that some other Veterans would exaggerate their PTSD symptoms to increase their level of financial compensation; however, we believe there may be more underreporting than over-reporting. If the net misclassification

of PTSD was 10% and it was non-differential by outcome, our observed RR would be the same (RR=1.4; 95% CI=1.1 to 1.7). If the exposure misclassification in our study was differential - for example, if PTSD were underreported among 10% of the Veterans who were hospitalized for MVC injuries and underreported among 20% of the Veterans who were not hospitalized for MVC injuries in our study - then our univariate results would be biased away from the null relative to the "true" unadjusted risk (RR=1.2; 95% CI=1.0 to 1.5). Therefore, potential exposure misclassification should be considered when interpreting the results of this study.

It is possible that Veterans in our study were misclassified with regards to MVC hospitalization status if they were hospitalized at facilities other than VA medical centers. If there was a 10% non-differential misclassification of MVC hospitalization status, then our results would be the same as the "true" RR (RR=1.4; 95% CI=1.1 to 1.7). If some Veterans' hospitalizations for MVCs were more likely to be classified correctly among those Veterans in our cohort with a VA PTSD diagnosis than those without such a diagnosis - for example, if the outcome were incorrectly misclassified as not hospitalized for MVC-related injuries among 10% of those given PTSD diagnoses and incorrectly misclassified among 20% of the Veterans who were not given PTSD diagnoses - then our results would be biased away from the null relative to the "true" unadjusted RR of 1.2 (95% CI=1.0 to 1.5). Therefore, it is plausible that the excess risk of MVC hospitalization attributable to PTSD diagnosis that we observed would be due to systematic bias rather than a "true" effect. However, we attempted to reduce the potential for this type of bias in our study by restricting our study to "frequent users" to increase the capture of information about hospitalizations due to MVC injuries.

Future researchers should consider other health conditions common among post-deployment Veterans as potential risk factors for MVC and should examine MVC injuries that did not solely result in hospitalizations. The VA is currently conducting a 10-year longitudinal study called the National Health Study for a New Generation of U.S. Veterans. This longitudinal study will provide further data on Veterans' risk of MVC and has the potential to improve upon the limitations of our current design.

Conclusions

Based on our results, PTSD appears to be an indicator rather than a causal factor for increased risk of MVC among post-deployment Veterans. The findings of our study represent OEF/OIF/OND Veterans who enrolled in VA healthcare within the first year post-deployment, who had at least five visits total, with at least one visit in the first year and at least one visit in either the fourth or fifth year, who survived all five years, and who received any VA medical diagnosis in the follow-up period. Additional research is needed to disentangle these complex relationships, and to explore risk factors for all MVCs among all Veterans whether or not they utilize VA.

MANUSCRIPT REFERENCES

1. **Knapik JJ**, Marin RE, Grier TL, et al. A systematic review of post-deployment injury-related mortality among military personnel deployed to conflict zones. BMC Public Health 2009;9:231.
2. **Waxwiler RJ**, Thurman D, Sneizek J, Sosin D, O'Nell J. Monitoring the impact of traumatic brain injury: a review and update. J Neurotrauma 1995;**124**:509-516.
3. **Gray GC**, Smith TC, Kang HK, et al. Are Gulf War Veterans suffering war-related illnesses? Federal and civilian hospitalizations examined, June 1991 to December 1994. Am J Epidemiol 2000;151:63e71.
4. **Kang HK**, Bullman TA. Mortality among US Veterans of the Persian Gulf War: 7-Year Follow-up. American Journal of Epidemiology 2001 September 01;154(5):399-405.
5. **USAA.** Returning Warriors: Driving Safety Report 2012. 2012:1-3.
6. **Bell NS**, Amoroso PJ, Wegman DH, et al. Proposed explanations for excess injury among Veterans of the Persian Gulf War and a call for greater attention from policymakers and researchers. Inj Prev 2001;7:4-9.
7. **American Psychiatric Association**. Task Force on DSM-V. Diagnostic and statistical manual of mental disorders: DSM-V-TR. Washington, DC: American Psychiatric Association; 2013.
8. **Boscarino JA**. External-cause mortality after psychologic trauma: the effects of stress exposure and predisposition. Compr Psychiatry 2006;47:503e14.

9. **Hermann BA**, Shiner B, Friedman MJ. Epidemiology and Prevention of Combat-Related Post-Traumatic Stress in OEF/OIF/OND Service Members. Military Medicine 2012; 177(8):1.
10. **Armed Forces Health Surveillance Center.** CTS Deployment File Baseline Report, Defense Manpower Data Center. Provided to VA Office of Public Health Epidemiology Program: March 4, 2013. https://www.dmdc.osd.mil/appj/dwp/reports.do?category=reports&subCat=milActDutReg Accessed: December 18, 2013.
11. **Gravely AA,** Cutting A, Nugent S, Grill J, Carlson K, Spoont M. Validity of PTSD diagnoses in VA administrative data: Comparison of VA administrative PTSD diagnoses to self-reported PTSD Checklist scores. J Rehabil Res Dev 2011;48(1):21-30.
12. **Haskell SG,** Brandt CA, Krebs EE, Skanderson M, Kerns RD, Goulet JL. Pain among Veterans of Operations Enduring Freedom and Iraqi Freedom: Do Women and Men Differ? Pain Med 2009;10(7):1167-73.
13. **U.S. Department of Veterans Affairs.** Office of Public and Intergovernmental Affairs Federal Benefits for Veterans, Dependents and Survivors Chapter 2 Service-Connected Disabilities. http://www1.va.gov/opa/publications/benefits_book/benefits_chap02.asp Updated: November 11, 2013. Accessed: December 11, 2013.
14. **Greenland S**, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiology 1999;10:37-48.
15. **SAS Institute Inc**. SAS System 9.3.

16. **Naumann B.** Incidence and Total Lifetime Costs of Motor Vehicle-Related Fatal and Nonfatal Injury by Road User Type, United States, 2005. Traffic Inj Prev 2010;11(4):353-360.
17. **Carlson KF**, Gravely AA, Noorbaloochi S, Simon AB, Bangerter AK, Sayer NA. Post-deployment injury among new combat veterans enrolled in Veterans Affairs (VA) healthcare. Inj Prev 2011;17:343-347.
18. **U.S. Department of Veterans Affairs.** Office of Public Health. Epidemiology Program. Analysis of VA Health Care Utilization among Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), and Operation New Dawn (OND) Veterans: Cumulative from 1st Qtr FY 2002 through 1st Qtr FY 2013 (October 1, 2001 – December 21, 2012). Released: March 2013. Available at: http://www.publichealth.va.gov/docs/epidemiology/healthcare-utilization-report-fy2013 qtr1.pdf Accessed: December 11, 2013.

TABLES

Table 1. Characteristics of 119,343 Iraq and Afghanistan War Veterans Who Were "Frequent Users" of Veterans Health Administration (VHA) Healthcare, by Hospitalization for MVC-Related Injuries, 2001-2011.

	Hospitalized	**Not Hospitalized**	**Total**
	(n=378)	**(n=118,965)**	**(n=119,343)**
Characteristic	**n (column %)**	**N (column %)**	**n (column %)**
Age			
18-24	192 (50.8%)	39,193 (32.9%)	39,385 (33.0%)
25-29	75 (19.8%)	23,905 (20.1%)	23,980 (20.1%)
30-39	51 (13.5%)	26,290 (22.1%)	26,341 (22.1%)
40+	60 (15.9%)	29,569 (24.9%)	29,629 (24.8%)
Missing	0 (0.0%)	8 (0.0%)	8 (0.0%)
Gender			
Female	22 (5.8%)	15,093 (12.7%)	15,115 (12.7%)
Male	356 (94.2%)	103,870 (87.3%)	104,226 (87.3%)
Missing	0 (0.0%)	2 (0.0%)	2 (0.0%)
Race/Ethnicity			
White	206 (54.5%)	62,506 (52.5%)	62,712 (52.5%)
Non-White	75 (19.8%)	34,451 (29.0%)	34,526 (28.9%)
Missing	97 (25.7%)	22,008 (18.5%)	22,105 (18.5%)
Marital Status			
Never married	226 (59.8%)	56,725 (47.7%)	56,951 (47.7%)
Married	128 (33.9%)	54,932 (46.2%)	55,060 (46.2%)
Divorced, Separated, or Widowed	23 (6.1%)	7,261 (6.1%)	7,284 (6.1%)
Missing	1 (0.3%)	47 (0.0%)	48 (0.0%)
Education			
High school diploma or less	337 (89.2%)	91,277 (76.7%)	91,614 (76.8%)
Some college	23 (6.1%)	13,061 (11.0%)	13,084 (11.0%)
Bachelor's, Professional Nursing Degree, or more	14 (3.7%)	13,263 (11.2%)	13,277 (11.1%)
Missing	4 (1.1%)	1,364 (1.2%)	1,368 (1.2%)

Table 1 Continued:

Characteristic	Hospitalized (n=378) n (column %)	Not Hospitalized (n=118,965) N (column %)	Total (n=119,343) n (column %)
Miles to nearest VA			
0-10	204 (54.0%)	69,318 (58.3%)	69,522 (58.3%)
11-25	126 (33.3%)	36,702 (30.9%)	36,828 (30.9%)
26-50	44 (11.6%)	11,448 (9.6%)	11,492 (9.6%)
50+	4 (1.1%)	1,103 (0.9%)	1,107 (0.9%)
Missing	0 (0.0%)	394 (0.3%)	394 (0.3%)
Branch of Service			
Air Force	24 (6.4%)	7,624 (6.4%)	7,648 (6.4%)
Army	267 (70.6%)	89,071 (74.9%)	89,338 (74.8%)
Coast Guard/ Navy	25 (6.6%)	8,663 (7.3%)	8,688 (7.3%)
Marines	62 (16.4%)	13,607 (11.4%)	13,669 (11.5%)
Component			
Active Duty	224 (59.3%)	51,022 (42.9%)	51,273 (42.9%)
Reserve/Guard	154 (40.7%)	67,943 (57.1%)	68,136 (57.1%)
Number of Deployments			
1 deployment	248 (65.6%)	72,101 (60.6%)	72,391 (60.6%)
>1 deployment	130 (34.4%)	46,864 (39.4%)	47,018 (39.4%)
Service Connection Status			
None	50 (13.2%)	33,247 (28.0%)	33,355 (27.9%)
0-40	66 (17.5%)	37,226 (31.3%)	37,295 (31.2%)
50+	262 (69.3%)	48,492 (40.8%)	48,759 (40.8%)

* One or more inpatient motor vehicle crash diagnoses during the first five years post-deployment.

Table 2. Relative Risk of Hospitalizations for MVC-Related Injuries by PTSD Diagnosis Status.

	Post-deployment hospitalization for MVC[*] (Inpatient, Years 1-5)			
Characteristic	**Hospitalized (n=373; 0.32%) N %**	**Not Hospitalized (n=117,178); 99.7%) n %**	**Univariate Model (n=117,551) RR (95% CI)**	**Multivariate Model (n=117,551) RR[§] (95% CI)**
PTSD Diagnoses[‖]				
Yes	111 (29.8%)	27,423 (23.4 %)	**1.4 (1.1-1.7)**	1.0 (0.8-1.2)
No	262 (70.2%)	89,755 (76.6%)	Referent	Referent

* One or more inpatient motor vehicle crash diagnoses during the first five years post-deployment.

§ Model adjusted for age, gender, race/ethnicity, number of deployments, branch, component, miles to the nearest VA, education, marital status, and service connection status.

|| Two or more outpatient encounters or one or more inpatient stays during the first year post-deployment in which an ICD-9-CM code for PTSD (309.81) was assigned.

CHAPTER 3: PUBLIC HEALTH IMPLICATIONS

Overview

Over two million American servicemen and servicewomen have served in combat zones in Afghanistan and Iraq (10), and motor vehicle crashes are the leading cause of death among combat Veterans during the first years post-deployment (1). Furthermore, driving is an important activity of daily living for Veterans' transition to civilian life including finding work and social support, and accessing health care. The intent and contribution of our research was to address the public health problem of increased risk of MVC-related hospitalizations among recent Veterans by helping investigate *why* this is a problem for Veterans. This study can increase awareness around this problem among providers, inform policy development on how to direct public health efforts and resources, and in turn, lead to assurance of appropriate future cultural norms, public health and medical services, innovative research, and informed workforce personnel.

Assessment

This study focused on assessment of the public health problem of post-deployment risk of hospitalization due to MVC events among recent Veterans who were frequent VA users from 2001 to 2011. The VHA administrative datasets can serve as a surveillance system, and future research should monitor this dataset for changes in the relative risk of MVC hospitalizations due to PTSD and other factors. We merged administrative data with military roster data, but future research should also enhance this surveillance by incorporating other data sources such as prescription and psychotropic medication records, police crash reports (e.g., information about blood alcohol content upon collision, speeding, and environmental factors which possibly contributed to the

MVC), electronic medical records from other hospitals and ambulatory care settings, military health records, health information gathered pre- and post-deployment, and data from surveys and information collected from advocacy and outreach organizations reaching subgroups of OEF/OIF/OND Veterans unconnected to the VA. Sharing and merging these datasets across institutions, particularly if the data were collected in a uniform and timely way, would lead to enhanced empirical research with greater generalizability.

We selected confounders based on an *a priori* directed acyclic graph (DAG), a way to conceptualize a theoretical model based on an understanding of the subject rather than on statistical associations between variables in a dataset (11). Once the DAG was created, it provided a road map for the statistical analysis estimating relative risk in this study. Reliance on statistical associations to determine which variables within the dataset should be adjusted for can lead to biased results when there is bias in the original data or when there are spurious associations between variables. Through the DAG we aimed to depict how demographics, military branch, military component, pre-deployment education, the number of deployments, service connection status and distance from Veterans' homes to the VA are factors we understand to occur upstream of VA diagnoses (including PTSD). We represented unidirectional relationships between these factors and PTSD and MVC hospitalizations, and therefore determined which factors should be adjusted for as potential confounders. Based on our current understanding of literature on Veterans' health, we represented relationships between PTSD and other diagnoses highly correlated with PTSD among post-deployment Veterans (traumatic brain injury, substance use disorder, sleep disorders and deprivation, chronic pain and other mental

health disorders) and relationships between those diagnoses and MVC injury. Because of the manner in which administrative data are collected, we expected these variables to be highly correlated since Veterans are screened for many conditions upon returning from theaters of combat and subsequent services and diagnoses are affected by access to the VA, proximity to the VA, service connection status, and cultural norms surrounding affiliation with the VA. In other words, the timing and presence of particular diagnoses may be as affected by VA access, policies, societal incentives and stigma as they are by the Veterans' true health status.

Age, marital status, education, military component and service connection status appear to be the confounders in the analysis that contribute to the elevated risk. In particular, service connection status may be an impactful confounder on the research question. As stated above, service connection "is a monetary benefit provided to Veterans and their dependents to compensate for disabilities incurred or aggravated during active service" (12). Furthermore, service connection status determines which Priority Group Veterans are assigned to, ranging from 1-8 with 1 being the highest priority, which in turn determines Veterans' eligibility for VA's comprehensive medical benefits package (13). Veterans with low or no service connection status may utilize other health care services outside the VA, not receive medical services, or only seek urgent medical services rather than preventive or ongoing care. It is possible that Veterans with no or low service connection status in our cohort were misclassified with respect to their PTSD and/or MVC hospitalization status.

Policy Development

There are numerous partners dedicated to developing policies that may prevent future MVC hospitalizations. These partners provide education about post-deployment driving difficulties, mobilize communities, and develop policies and programs to support Veterans in this regard. In New York State, the VA and the Department of Motor Vehicles created a "motor vehicle accident prevention course," which they encourage all returning active duty service members to complete in a classroom or online. Their message to Veterans is, "If you have returned from a combat deployment you should refresh your knowledge of American motor vehicle driving rules and safe driving practices. You owe it to yourself and to your family to make a safe transition to post-deployment life. Welcome Home." The New York project incentivizes Veterans to take the courses with reduced motor vehicle insurance premiums and reduction in points related to traffic tickets (14). This program has the potential to reduce MVC hospitalizations nationwide among 'frequent VA user' Veterans if replicated in other states, and particularly if education and incentives were tailored to Veterans who are given PTSD diagnoses through the VHA.

On a national scale, the VA has the Veterans' Safe Driving Initiative, which includes an information campaign, a strategic research plan, and a car racing legend, Richard Petty, as its spokesperson (15). The VA's Veteran Health Library says, "Be aware that motor vehicle crashes are the leading cause of death in Veterans in the early years after returning home from deployment" (16). We hope this study can impact the information the VA shares with Veterans about MVC risk. Decisions on programs and on national comprehensive policy affecting Veterans' access to healthcare and education

around post-deployment health should be made on the basis of empirical evidence when possible and on the expertise provided by Veterans.

Assurance

We envision public health assurance regarding post-deployment MVC injuries from the VA and other partners that is customized to subgroups of Veterans. The VA should assure the health services and personnel providing care for Veterans with PTSD are competent and informed about the elevated risk of hospitalization due to MVC-related injuries among this subgroup of Veterans. In order to prevent some MVC hospitalizations, providers may want to ask their patients with PTSD about driving experiences in order to seek information about whether their individual patient might be at risk for MVC. It is understood that Veterans will want assurance this research does not add to stigma for Veterans or propose restricting Veterans' driving rights. Finally, it is imperative that the VA maintains the Veterans' Safe Driving Initiative, competent providers, researchers and staff, and programs at a level of service needed to reduce the number of OEF/OIF/OND Veterans hospitalized due to MVC-related injuries.

Future Research

The VA is currently conducting a 10-year longitudinal study called the National Health Study for a New Generation of U.S. Veterans, where researchers have surveyed 60,000 recent Veterans and asked 1,000 of the Veterans for permission to review medical records. The questionnaire covers topics related to our study, including hospitalizations, "accidents," head injuries, PTSD, and behaviors such as alcohol use, motorcycle helmet use, seatbelt use, and speeding. The purpose of the study is to "provide insight on the overall health of recent Veterans, improve VA's understanding of what health services

Veterans need, and maximize the quality of care that VA offers" (17). Hopefully this longitudinal study will provide further data on Veterans' risk of MVC and will improve upon the limitations of our current design.

An ideal analysis for these new data would use time-to-event analysis modeling time to injury due to MVC. A similar study could be conducted where some explanatory variables would remain fixed over time (e.g. gender, age, race, military component) and others might change over time (PTSD status, distance to nearest VA, marital status). This longitudinal study design would be able to use more information than our current design. For example, in our study, we assume "frequent user" Veterans were followed for five years, but it's possible they were followed only for four years. With these new data, researchers could include Veterans who died before five years in the study, which may be important if they died because of a MVC. After the MVC event or death, they would be censored rather than following all Veterans for five years post-deployment. Researchers would know at what point in the first year they enrolled, and know with greater precision whether or not the PTSD symptoms preceded the MVC hospitalizations. This study design may address limitations of our current study since it will reach a greater cross-section of recent Veterans, including OEF/OIF/OND Veterans and Veterans deployed to other conflict zones worldwide, and it will reach "non-frequent VA users" as well as "frequent VA users". This type of study may improve upon potential misclassification bias in our current study since Veterans would self-report on MVC hospitalizations and ambulatory care in non-VA settings. Therefore, the researchers will be able to conduct studies with these data that will have greater internal and external validity than our

current study, and will contribute important knowledge to prevent and reduce the severity of MVC injuries among recent Veterans.

CHAPTER 4: REFERENCES

(1) Knapik JJ, Marin RE, Grier TL, et al. A systematic review of post-deployment injury-related mortality among military personnel deployed to conflict zones. BMC Public Health 2009;9:231.

(1) CDC. Postservice mortality among Vietnam Veterans. The Centers for Disease Control Vietnam Experience Study. JAMA 1987 Feb 13;257(6):790-795.

(2) Kang HK, Bullman TA. Mortality among US Veterans of the Persian Gulf War: 7-Year Follow-up. American Journal of Epidemiology 2001 September 2001;154(5):399-405.

(3) Waxwiler RJ, Thurman D, Sneizek J, Sosin D, O'Nell J. Monitoring the impact of traumatic brain injury: a review and update. J Neurotrauma 1995;124:509-516.

(4) Gray GC, Smith TC, Kang HK, et al. Are Gulf War Veterans suffering war-related illnesses? Federal and civilian hospitalizations examined, June 1991 to December 1994. Am J Epidemiol 2000;151:63e71.

(5) Fett MJ, Nairn JR, Cobbin DM, Adena MA. Mortality among Australian conscripts of the Vietnam conflict era. II. Causes of death. Am J Epidemiol 1987 May;125(5):878-884.

(6) Bell NS, Amoroso PJ, Wegman DH, Senier L. Proposed explanations for excess injury among Veterans of the Persian Gulf War and a call for greater attention from policymakers and researchers. Inj Prev 2001 Mar;7(1):4-9.

(7) Dao J. Back From War, Fear and Danger Fill Driver's Seat. The New York

Times 2012 Jan 10.

(8) Berkowitz B. Returning soldiers have more car crashes: study. Reuters 2012 April 24.

(9) USAA. Returning Warriors: Driving Safety Report 2012. 2012:1-3. Armed Force Health Surveillance Center. CTS Deployment File Baseline Report, Defense Manpower Data Center. Provided to Epidemiology Program: March 4, 2013.

(10) Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiology 1999;10:37-48.

(11) U.S. Department of Veterans Affairs. Office of Public and Intergovernmental Affairs Federal Benefits for Veterans, Dependents and Survivors Chapter 2 Service-connected Disabilities. http://www1.va.gov/opa/publications/benefits_book/benefits_chap02.asp Updated: November 11, 2013. Accessed: December 11, 2013.

(12) U.S. Department of Veterans Affairs. Health Benefits Home. Priority Groups Table. http://www.va.gov/healthbenefits/resources/priority_groups.asp Updated: August 20, 2012. Accessed: December 11, 2013.

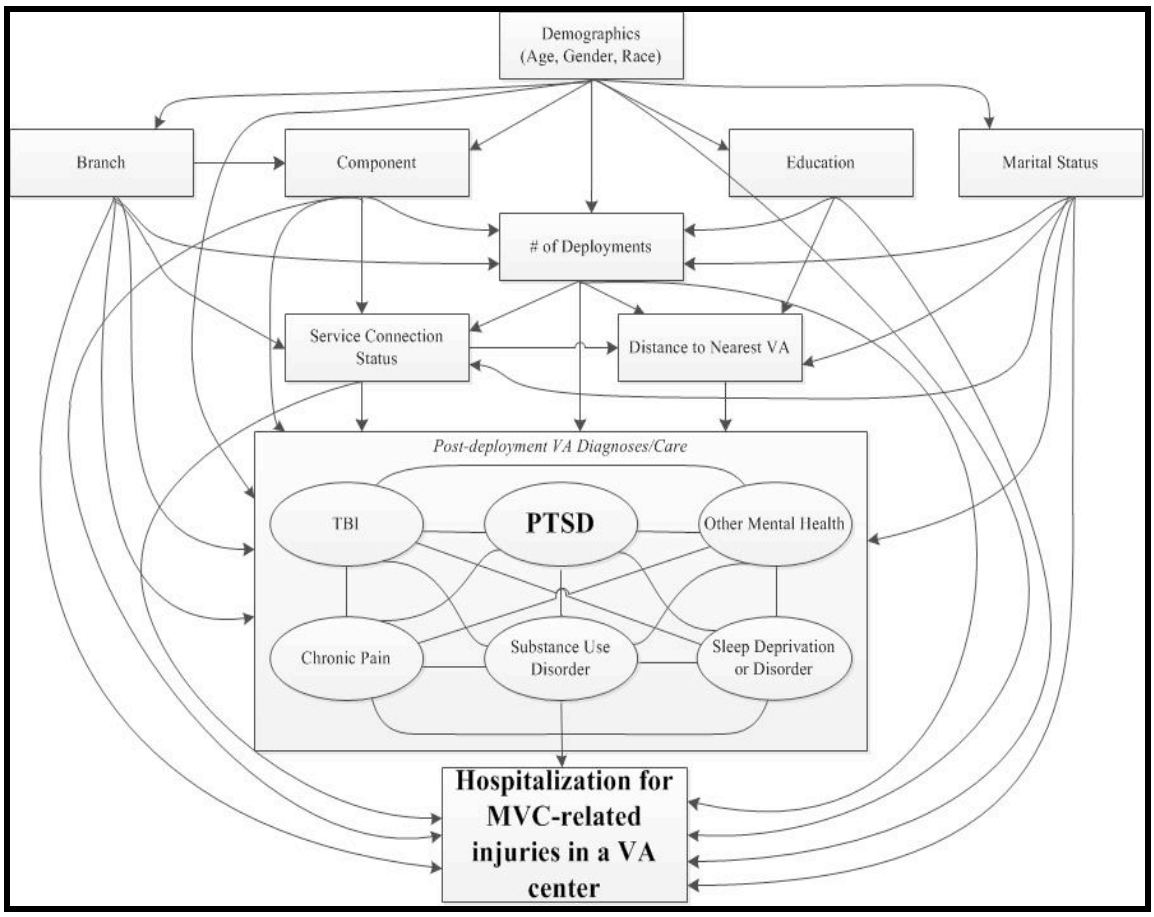
(13) New York State Division of Military and Naval Affairs. Motor Vehicle Accident Prevention Course For Post-Deployment Combat Veterans. http://dmna.ny.gov/vet_mva_prevention.pdf Accessed on November 22, 2013.

(14) U.S. Department of Veterans Affairs. Veterans Health Administration. Veterans' Safe Driving Initiative. http://www.va.gov/health/safedriving/ Updated: September 9, 2013. Accessed: November 22, 2013.

(15) United States Department of Veterans Affairs. My HealtheVet. Veterans Health Library. Your source for health information. Be Safe. http://www.veteranshealthlibrary.org/HealthyLiving/Safety/142,HLM009_V Accessed on November 22, 2013.

(16) United States Department of Veterans Affairs. Public Health. National Health Study for a New Generation of U.S. Veterans. http://www.publichealth.va.gov/epidemiology/studies/new-generation-study.asp Updated: August 22, 2013. Accessed on November 22, 2013.

APPENDIX A: Directed Acyclic Graph (DAG)



The DAG depicts associations between PTSD, Hospitalizations for MVC-related injuries and other exposures before, during and after deployment which we hypothesized were important to consider in relation to our key study question.

APPENDIX B: Frequency of First MVC-Related Hospitalizations.

Year Post-deployment	Number of Veterans with their first hospitalization for MVC-injuries in each year	Percentage of first hospitalizations for MVC-injuries in each year
Year 1	166	44%
Year 2	79	21%
Year 3	66	17%
Year 4	41	11%
Year 5	26	7%
Total	378	100%

These are the number of Veterans, of the 119,343 in the cohort, who had their first hospitalization for MVC-related injuries in each of the first year years post-deployment. These are mutually exclusive values.