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14. ABSTRACT

Purpose: The purpose of this retrospective study was to determine temporal patterns and relationships between sleep disorders, mental disorders, and TBI in service members who were deployed from 2001 to 2011. **Description:** Longitudinal medical surveillance data from two electronic medical charting systems that included over 288,000 deployed service members with a diagnosed sleep disorder were used. A series of descriptive statistics, logistic regression analysis, and Chi-square tests for independence were used to answer the research questions. **Findings:** Results showed that insomnia, sleep disordered breathing, substance use disorders and adjustment disorders occurred most frequently in this sample and that pre-existing sleep disorders are predictive of mental disorders after deployment but TBI was not. Those with TBI were diagnosed most frequently with insomnia and parasomnias, and temporally, mental disorders usually preceded a sleep disorder diagnosis. **Implications for Military Nursing:** First, the relationship between pre-existing sleep disorders and mental disorders following a deployment can help direct health care providers in making recommendations for suitability for deployment. Second, this study identifies the top mental disorders and sleep disorders diagnosed in deployed service members, which provides potential for health care providers and commands to increase their observation of returning service members for these disorders in order to decrease risk of future disease and occupational problems. Finally, this study provides an in depth analysis of the frequencies and types of sleep disorders that are associated with TBI. The timely identification and treatment of sleep disorders is essential because these disorders increase risk for mental disorders and have the potential impede recovery from TBI.

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Abstract

Purpose: The purpose of this retrospective study was to determine temporal patterns and relationships between sleep disorders, mental disorders, and TBI in service members who were deployed from 2001 to 2011.

Description: Longitudinal medical surveillance data from two electronic medical charting systems that included over 288,000 deployed service members with a diagnosed sleep disorder were used. A series of descriptive statistics, logistic regression analysis, and Chi-square tests for independence were used to answer the research questions.

Findings: Results showed that insomnia, sleep disordered breathing, substance use disorders and adjustment disorders occurred most frequently in this sample and that pre-existing sleep disorders are predictive of mental disorders after deployment but TBI was not. Those with TBI were diagnosed most frequently with insomnia and parasomnias, and temporally, mental disorders usually preceded a sleep disorder diagnosis.

Implications for Military Nursing: First, the relationship between pre-existing sleep disorders and mental disorders following a deployment can help direct health care providers in making recommendations for suitability for deployment. Second, this study identifies the top mental disorders and sleep disorders diagnosed in deployed service members, which provides potential for health care providers and commands to increase their observation of returning service members for these disorders in order to decrease risk of future disease and occupational problems. Finally, this study provides an in depth analysis of the frequencies and types of sleep disorders that are associated with TBI. The timely identification and treatment of sleep disorders is essential because these disorders increase risk for mental disorders and have the potential impede recovery from TBI.

TSNRP Research Priorities that Study or Project Addresses

Primary Priority

Force Health Protection:	☒ Fit and ready force ☒ Deploy with and care for the warrior ☐ Care for all entrusted to our care
Nursing Competencies and Practice:	☐ Patient outcomes ☐ Quality and safety ☐ Translate research into practice/evidence-based practice ☐ Clinical excellence ☐ Knowledge management ☐ Education and training
Leadership, Ethics, and Mentoring:	☐ Health policy ☐ Recruitment and retention ☐ Preparing tomorrow's leaders ☐ Care of the caregiver
Other:	☐

Progress Towards Achievement of Specific Aims of the Study or Project

This study was completed and presented as a requirement for a doctor of philosophy on the 26th of September, 2014 at the University of Pennsylvania's School of Nursing.

Findings related to each specific aim, research or study questions, and/or hypothesis

Purpose & Research Questions

Concomitant sleep disorders, mental disorders, and TBI negatively affect personal work performance, suitability for military service, and the overall mission of the United States Military. Yet the temporal emergence of these diagnoses has not yet been elucidated. For example, are sleeps disorders diagnosed prior to the emergence of a mental disorder (e.g., PTSD) or are mental disorders diagnosed prior to the emergence of a sleep disorder? Does the presence of a deployment-related TBI influence the temporal sequence of the emergence of any of these disorders individually or collectively? The extant knowledge has not adequately answered these questions. Therefore, the purpose of this retrospective study was to determine the relationships and temporal patterns among sleep disorders, mental disorders, and TBI in service members who deployed between 2001-2011.

To fulfill this purpose, longitudinal medical surveillance data from two electronic medical charting systems, the Defense Medical Surveillance System (DMSS) and the Defense Medical Epidemiology Database (DMED) were used. Specifically a dataset that includes over 288,000 deployed service members who at some point during a 10 year time period had been diagnosed with a sleep disorder was extracted for analysis. These clinical and administrative data were used to answer the following research questions:

RQ1: What is the distribution of sleep disorders diagnoses?
RQ2: What mental disorders occur most often with each sleep disorder diagnosis?
RQ3: Are sleep disorders different in patients with TBI versus those without TBI?
RQ4: What is the temporal sequence of emergence of mental disorders and sleep disorder diagnosis in deployed service members?
RQ5: Does a sleep disorder diagnosed prior to deployment increase the likelihood of having a mental disorder or TBI diagnosis post deployment?

Sampling Diagram and Descriptive Statistics

The sample was drawn from 288,387 service members between the ages of 18 and 55 years, who had deployed at least once, and who were diagnosed with at least one sleep disorder prior to or after the first day of the first deployment. Study participants entered the data set the first day of their first deployment (within the timeframe of 2001-2011) and exited the study at the end of the study period (2011) or when they separated from the military, whichever came first. Service members with more than 15 deployments (n=41) were removed as this number of deployments is atypical and may reflect service

members coming into a war zone for a short visit or medical and flight personnel responsible for transportation in and out of theater. Incidence of disease was determined by identifying the first recorded disorder diagnosed by an ICD9 code for each participant indexed by the first day of the participants' first deployment within the timeframe of 2001-2011. The sample size changed with each research question.

The final sample consisted of 288,347 service members. The number of service members with a sleep disorder diagnosed prior to their first deployment was n=24,159 and those without a sleep disorder diagnosed prior to their first deployment was 264,187 (see Figure 1). Figure 2 provides an overview of the percentages of sleep disorders, mental disorders, and TBI in participants without pre-existing sleep disorders. The sample was predominately male (87.7%), white (61.6%), junior enlisted-E1-E4 (50.0%), in a military occupation of logistics (30.1%) or a ground combat element (20.6%), with a mean age of 28 years (SD 7.6). Twelve percent (12.3%) of the sample was female, 3.7% were Asian Pacific Islanders, 20% were black, 10.1% were Hispanic, and 0.9% was American Indian/Alaskan Native. Sixty six percent of the participants were deployed to Iraq and 32.6% were deployed to Afghanistan. The remainder of the sample was deployed with operation New Dawn which represents those in Iraq after the combat mission had been completed. Participants deployed an average of 1.9 times (SD 1.2) for an average of 249 days (SD 144.1). Participants were in the data set for a duration of 1,984 days or on average 66 months (SD 988.6 days or 32.9 months). More than half the participants (52.7%) were in the data set for more than 5 years with the largest percent (13.9%) in the data set more than 9 years.

In addition to describing the total sample, participants with and without pre-existing sleep disorders were compared on key demographic and military characteristics. A larger percentage of the participants with pre-existing sleep disorders served in headquarters, wing, and medical military occupations. Their average age at first deployment was older (31.3 years, SD 8.3), and the majority was senior enlisted (E5-E9). Interestingly, more women had a pre-existing sleep disorder (13.1%) compared with men (7.7%). Finally, participants with pre-existing sleep disorders had fewer average deployments (1.5, SD 0.9) and average deployed days (229, SD 132.4) compared with the participants without sleep disorders (1.9, SD 1.2 and 251, SD 145), respectively.

Figure 1: Sample Description

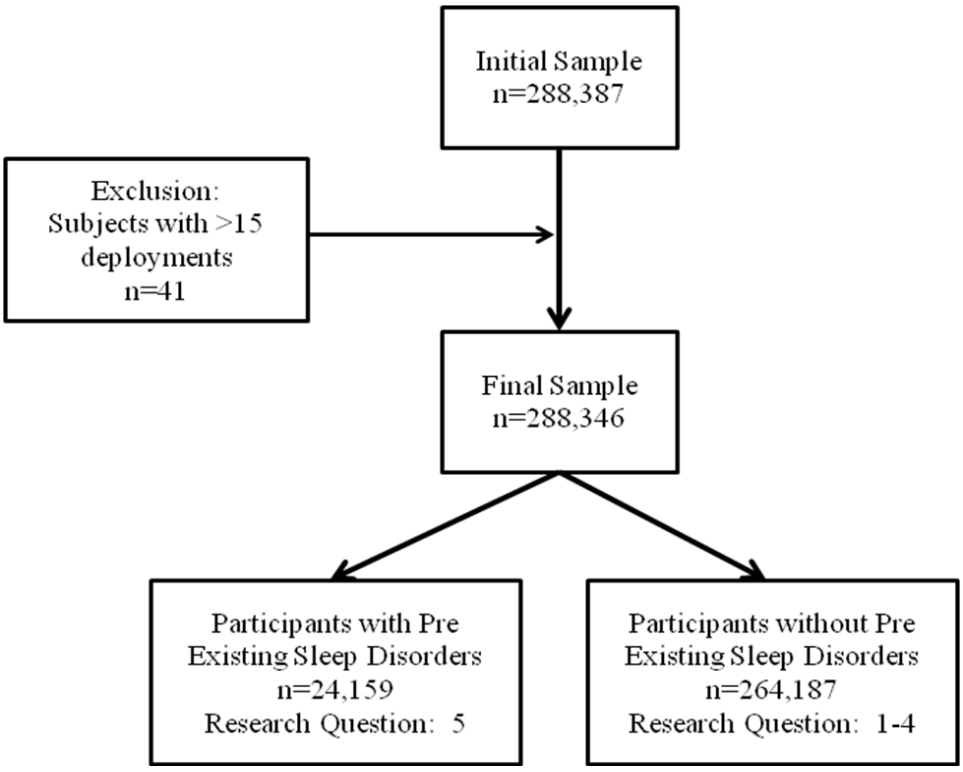
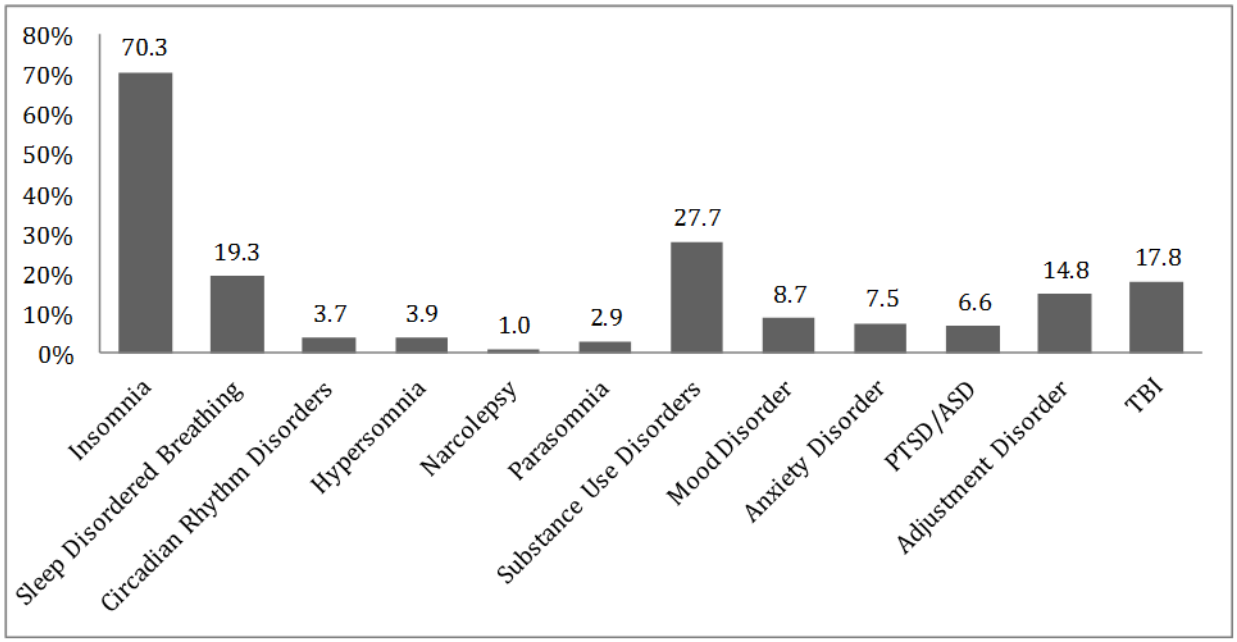


Figure 2: Percentages of Sleep Disorders, Mental Disorders, and TBI in Participants without Pre-existing Sleep Disorders

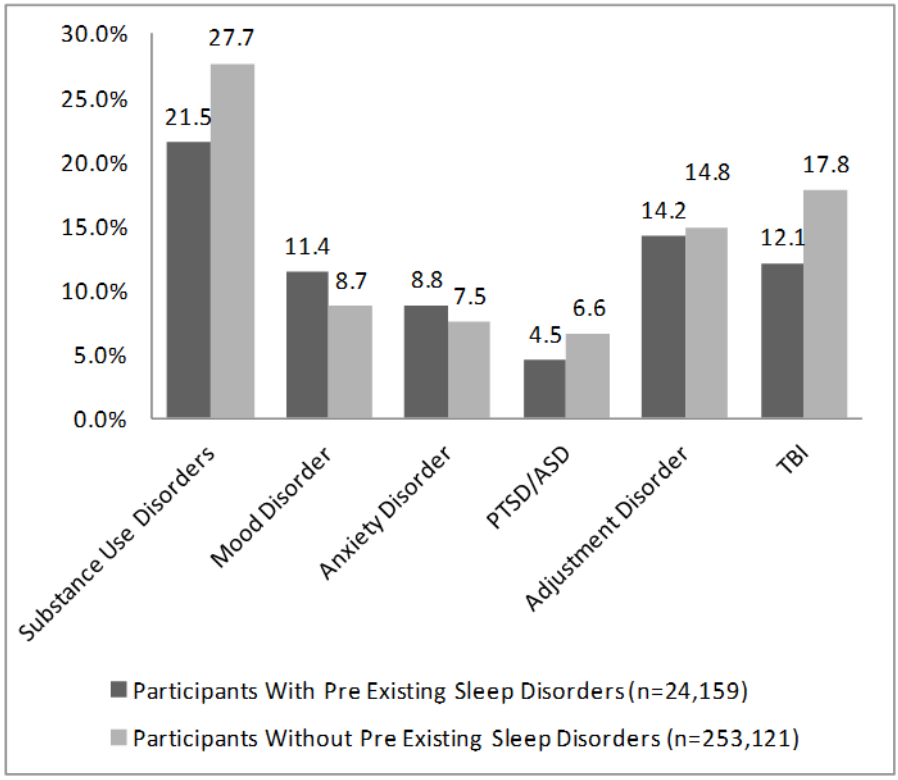


Mental Disorders

Figure 3 shows the frequencies of mental disorders in participants with and without preexisting sleep disorders. The following analysis includes *only the sample of participants without a preexisting sleep disorder*. A mental disorder diagnosis was identified if listed as the first diagnosis on a specific encounter date; participants with secondary diagnoses (n = 11,066) were excluded. The remaining 165,587 study participants diagnosed with a primary mental disorder represent 65.4% of those participants without a pre-existing sleep disorder (n=253,121). More than one in four (27.7%) of the sample with mental disorders had a substance use disorder, 8.7% had a mood disorder (inclusive of depression and bipolar disorders), 7.5% had an anxiety disorder (exclusive of traumatic stress disorders), 6.6% had PTSD, ASD, or Military Combat Operational Stress (V code), and 14.8% had an adjustment disorder.

Figure 3

Percentages of Mental Disorders and TBI in Deployed Military Service Members



Of those diagnosed with a mental disorder, visual inspection of the data suggest that there were a higher percentage of white married males, junior enlisted (E1-E5), and service members serving in Logistics and Ground Combat Military occupations. Male service members overall had more mental disorders when compared with females. The most common disorders in men were substance use disorders (44.6%), adjustment disorders (22.1%), and mood disorders (11.7%). In female service members, adjustment disorders (27%), substance use disorders (26.6%), and mood disorders (24.4%) were the

most common. Of note, the highest percentages of PTSD/ASD were found in service members serving in the ground combat element (32.9%), logistics (28.2%), and in the headquarters element (15.6%). In all types of military occupations, substance use disorders and adjustment disorders were the first and second most frequently diagnosed disorders.

Comorbid mental disorders in participants were described using the first two mental disorders diagnosed for each participant (Table 1). Any participant receiving one or more separate diagnoses on the same day or visit was included and each participant could be represented in multiple cells. Comorbid substance use and adjustment disorders occurred the most frequently (18.2%), followed by substance use and mood disorders (16.3%), and anxiety disorders and adjustment disorders (15.1%). As a whole, those without pre-existing sleep disorders had more comorbid substance abuse disorders and more comorbid PTSD and ASD disorders when compared with those with pre-existing sleep disorders. Those participants with pre-existing sleep disorders had more comorbid anxiety disorders.

Traumatic Brain Injury

The first identified TBI diagnosis for each participant was used in this analysis. Overall, there were 50,071 (17.4%) cases of TBI in the total sample of 288,246 participants; 2,924 (12.1%) in participants with pre-existing sleep disorders, and 47,147 (17.8%) in participants without pre-existing sleep disorders. Those with TBI were mostly men (93.1%), young (mean age of 25 years), overwhelmingly junior enlisted (E1-E4, 69.1%), and serving most often in the ground combat element and logistics fields (38.9% and 28.9% respectively). Comorbid mental disorders with TBI are as follows (information not shown in table): substance use disorders (33.8%), mood disorders (9.2%), anxiety disorders (9.6%), PTSD/ASD (12.1%), and adjustment disorders (20.8%).

Table 1

Comparing Deployed Military Service Members With and Without Sleep Conditions and Comorbid Mental Disorders.

	With Pre-Existing Sleep Disorder n=24,159		Without Pre-Existing Sleep Conditions n=264,187		*p* value
	n	%	n	%	
Co Morbid Disorders					
Substance and Mood	3,871	16	43,049	16.3	0.273
Substance and Anxiety	3,274	13.6	37,466	14.2	0.007
Substance and PTSD and ASD	2,407	10	35,102	13.3	<0.00
Substance and Adjustment	3,994	16.5	47,952	18.2	<0.00
Mood and Anxiety	4,026	16.7	39,231	14.8	<0.00
Mood and PTSD and ASD	3,000	12.4	37,555	14.2	<0.00
Anxiety and PTSD and ASD	2,638	10.9	33,366	12.6	<0.00
Anxiety and Adjustment	3,731	15.4	39,755	15.1	0.100
PTSD and ASD and Adjustment	2,885	11.9	37,407	14.2	<0.00

Note: frequencies of comorbid disorders are taken from first two mental disorders per subject. Frequencies and percent will total greater than 100%.

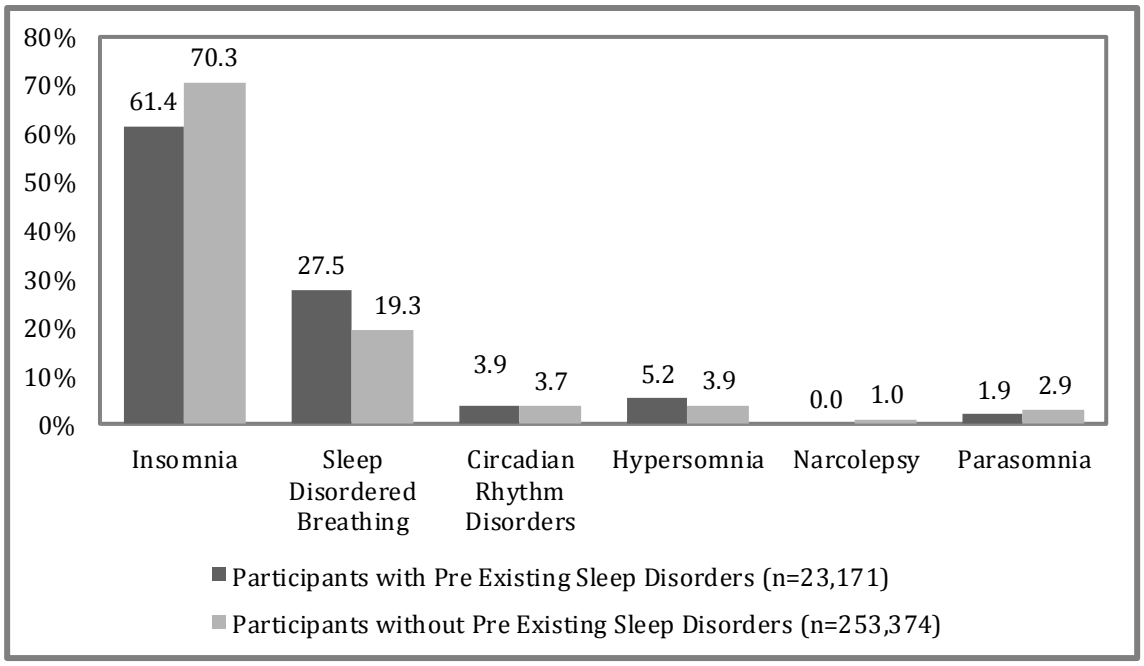
Results

Research question 1: Describe the distribution of sleep disorder diagnoses.

The first step in this analysis was to limit the sample to those participants without a pre-existing sleep disorder. The unit of analysis was the individual participant. To identify the frequencies of a single sleep disorder category per participant, the first incidence of a sleep disorder category was used. A series of descriptive statistics were then used to identify the frequencies and percentages of each diagnosed sleep disorder during and after deployments. This analysis was followed by continuous and categorical summaries describing the demographic characteristics associated with each disorder at a unit level. Next, an analysis was completed to determine the time frame that the diagnosis of the first sleep disorder was made in the following context: during a deployment or following a deployment. Finally, the data were examined for those participants with two or more diagnosed sleep disorders and the types and combinations of comorbid sleep diagnoses were described.

The distribution of sleep disorders is described for 253,374 participants without a pre existing sleep disorder based on the first incidence of a single sleep disorder diagnosed. Those with a primary and secondary sleep disorder diagnosed on the same day were dropped from the sample (n=10,813). Seventy percent (70.3%) of the participants were diagnosed with insomnia, 19.3% had sleep disordered breathing, 3.9% had hypersomnia, 3.7% had circadian rhythm disorders, 2.9% had parasomnias, and less than 1% had narcolepsy (see Figure 4).

Figure 4: Frequency of Sleep Disorders Diagnosed after the First day of the First Deployment in Participants with and without Pre Existing Sleep Disorders



Overall, the highest percentages of sleep disorders were in white married males, in junior enlisted (E1-E4) and senior enlisted (E5-E9), and in those serving in logistics military occupation specialties. Of note, circadian rhythm disorders were found most often in those serving in the wing (36.8%), and parasomnias (30.4%) were found most often in the ground combat element, and insomnia (31.1%) was found most often in those serving in the logistics field. Insomnia (68.5%), sleep disordered breathing (20.9%), and hypersomnia (4.1%) were the most frequently diagnosed sleep disorders in men, and insomnia (83.2%), sleep disordered breathing (7.6%), and circadian rhythm disorders (4.4%) were the most common in women. Those with sleep disordered breathing tended to be older (average of 31.9 years), mid-grade enlisted (E5-E9), and were more frequently represented in the data set for greater than nine 9 years. Those with insomnia were younger (average age 26.8 years), junior enlisted (E1-E4), and in the data set for 2-3 years more often.

In junior enlisted (E1-E4), insomnia occurred most frequently (n=105,568) followed by sleep disordered breathing (n=13,568). In mid-grade to senior enlisted (E5-E9), insomnia was most common (n=54,898) followed by sleep disordered breathing (n=27,017). Insomnia and parasomnias were more common in those who were in the data set for two to three years while sleep disordered breathing, circadian rhythm disorders, and hypersomnia were most common in those who were in the data set more than nine years.

In order to examine comorbid sleep disorders, the first type of sleep disorder category per participant was used instead of the first incidence. Those with one or more disorders diagnosed on the same day were included in this sample. Comorbid sleep disorders were common, occurring in 34.2% (n = 90,488) of the sample. The most common comorbid sleep disorder combinations were: sleep disordered breathing and insomnia (n=33,558), sleep disordered breathing/insomnia/hypersomnia (n=15,288), sleep disordered breathing and hypersomnia (n=12,162), insomnia and parasomnia (n=6,045), sleep disordered breathing/insomnia/parasomnia (n=4,676), insomnia and hypersomnia (n=4,421), insomnia and circadian rhythm disorders (n=3,343), sleep disordered breathing and parasomnia (n=1,708), and sleep disordered breathing/circadian rhythm disorders/insomnia (n=1,178).

Research question 2: Describe what mental disorders occur most often with each sleep disorder.

Mental disorders that occurred with each sleep disorder was defined as any mental disorder diagnosed within a 24 month period (12 months before and 12 months after) of a first incidence of a sleep disorder diagnosis. The presence of each mental disorder was categorized as yes (1) and the absence of each disorder was categorized as no (0). Then, mental disorders that were diagnosed within 24 months (12 months before to 12 months after) the first incidence of sleep disorder was identified. Descriptive statistics were used to identify the frequencies and percentages of the defined disorders at a unit level.

A total of 154,036 participants with mental disorders were diagnosed within 24 months of a sleep disorder (see table 2). Substance use disorders occurred most often (42.3%) followed by adjustment disorders (22.7%) and mood disorders (13.3%). Only five diagnoses of narcolepsy were found and therefore are not included in further analysis for this research question. Substance use disorders were the most frequently diagnosed mental disorder in all sleep disorder categories; insomnia was the most frequently diagnosed sleep disorder in all mental disorders.

Table 2

Frequency of Mental Disorders Diagnosed Within 24 Months of First Incidence of Sleep Disorder by Type

	Insomnia		Sleep Disordered Breathing		Circadian Rhythm Disorders		Hypersomnia		Parasomnia		Total
	n	%	N	%	n	%	n	%	n	%	
Substance Use Disorder	47,641	*40.5* ***73.1***	11,581	*50.3* ***17.7***	1,784	*49.5* ***2.7***	2,241	*46.9* ***3.4***	1,923	*37.1* ***2.9***	65,172
Adjustment Disorder	27,993	*23.8* ***79.9***	4,141	*18* ***11.8***	771	*21.3* ***2.2***	948	*19.9* ***2.7***	1,186	*22.9* ***3.4***	35,039
Anxiety Disorder	13,636	*11.6* ***77***	2,394	*10* ***13.5***	399.*06/**5***	*11* ***2.2***	538	*11.3* ***3.0***	728.*05*	*14* ***4.1***	17,697
Mood Disorder	15,794	*13.5* ***77***	2,948	*12.8* ***14.4***	415	*11.5* ***2.0***	688	*14.4* ***3.4***	652	*12.6* ***3.2***	20,497
PTSD/ASD	12,389	*10.6* ***79.2***	1,948	*8.5* ***12.5***	239	*6.62* ***2.3***	361	*7.56* ***2.3***	693	*13.4* ***4.4***	15,631
Total	117,453		23,012		3,608		4,776		5182		154,036

Note: data shows frequencies with column percentages in normal font/ row percentages in bold italics

Research question 3: Are sleep disorders different in patients with TBI versus those without TBI?

In research question three the sample was limited to those participants without pre-existing sleep disorder or TBI diagnosed prior to the first deployment. Initially, a series of univariate statistics were conducted to examine the distribution of time lapse between the first recorded sleep disorder (the anchor) and a diagnosis of TBI. The interquartile range, between the 25th and 75th percentile, was 389 days. Therefore, the decision was made to include only those participants who were diagnosed with a TBI within 365 days ± of the first sleep disorder diagnosed. A series of frequencies were then completed to identify V codes to ascertain the severity of the TBI (mild, moderate, and severe). Those without a severity code were eliminated from the analysis. Sleep disorders were collapsed into the same categories as research question number two. TBI was dichotomized into TBI/ yes or present and TBI/no or absent. A series of individual Chi Square tests of independence were completed for each sleep disorder category and presence or absence of TBI. The final analytic step was to describe the sleep disorders by TBI severity category.

There were 45,632 study participants in whom a TBI was diagnosed 365 days before or after the first sleep disorder was diagnosed. Analysis was conducted on the subset of 26,161 participants who had a V code for TBI severity. Over half (58.2%) were classified as having mild TBI, 0.3% with moderate TBI, 41.5% with severe TBI, and 27.8% were unknown.

The TBI sample was compared to the 207,742 participants without a diagnosis of TBI. Participants with TBI had more insomnia and parasomnias when compared with those without TBI ($p<0.001$). Sleep disordered breathing, circadian rhythm sleep disorders, and hypersomnia are more common in those participants without a TBI ($p<0.001$) (see Table 3). In terms of severity of TBI, insomnia, circadian rhythm disorders, sleep disordered breathing, and hypersomnia occurred more frequently in participants with mild TBI, and parasomnia occurred more frequently in participants with severe TBI (see Table 4). A chi-square test of independence was performed to examine the relation between types of sleep disorders and severity of TBI. The relationships between sleep disordered breathing χ^2 (2, N=18,014) = 41.6425, $p<0.001$, Cramer's V = 0.0481, insomnia χ^2 (2, N=18,014) = 93.1642, $p<0.001$, Cramer's V = 0.0719, and parasomnia χ^2 (2, N=18,014) = 70.8302, $p<0.001$, Cramer's V = 0.0622, and severity of TBI were significant.

Table 3

Differences in Sleep Disorders among Participants with and without a TBI

	Entire Sample n=233,903		With TBI n=26,161		Without TBI n=207,742	
	n	%	n	%	n	%
Sleep Disorders						
Sleep disordered breathing	48,877	19.3	2,298	8.8	44,083	21.2*
Circadian rhythm sleep disorders	9,306	3.7	310	1.2	8,561	4.1*
Insomnia	178,030	70.3	21,726	83*	140,971	67.9
Narcolepsy	8				7	
Parasomnia	7,319 0	2.9	1,397	5.3*	5,274	2.5
Hypersomnia	9,834	3.9	429	1.6	8,846	4.3*

Note: * $p<0.001$

Table 4

Sleep Disorders and Severity of TBI

	Mild TBI		Moderate TBI		Severe TBI		Total
	n	%	n	%	n	%	
Insomnia	9,024	59.7	42	0.3	6,046	40	15,112
Sleep disordered breathing	690	50	6	0.43	685	49.6	1,381
Circadian rhythm sleep disorders	130	65			69	34.5	200
Hypersomnia	134	60.7			100	47	234
Narcolepsy					1	100	1
Parasomnia	499	45.9			583	53.6	1,086

Note: Table represents frequencies and row percentages

Research question 4: What is the temporal sequence of emergence of mental disorders and sleep disorder diagnosis in deployed service members?

Participants with a pre-existing sleep disorder and TBI were excluded and the analysis was conducted on the subset of participants who were diagnosed with both a mental disorder AND a sleep disorder. The mental disorder and sleep disorder diagnoses were categorized as in research question two. Participants were then divided into three groups: 1) those in whom the mental disorder was diagnosed prior to the sleep disorder; 2) those in whom the sleep disorder was diagnosed prior to the mental disorder; and 3) those in whom the mental disorder and sleep disorder were diagnosed at the same time (defined if any sleep and mental disorder were diagnosed within three days of each other). Each pattern of emergence was described by frequencies. Then, each pattern group was examined using descriptive statistics and cross-tabulations for the following salient characteristics: age, sex, military occupation code, rank, number of deployments, location of deployment, and the different types of mental disorder and sleep disorder categories.

A total of 134,025 participants were excluded, leaving 154,321 participants. Mental disorders diagnosed prior to sleep disorders occurred most frequently (64.4%), followed by sleep disorders diagnosed prior to mental disorders (24.9%), and both groups of disorders diagnosed at the same time occurred only 10.7% of the time.

The three groups based on the temporal emergence of mental and sleep disorders were compared on demographic characteristics (age, sex, military occupation code, rank, number of deployments, location of deployment, and type of mental disorder). Those with sleep disorders diagnosed at the same time as mental disorders were younger, were junior enlisted (E1-E4), a higher percentage were from the ground combat element, had less time in the dataset, and had fewer deployments than those in the other groups .

Each group was then divided by the individual mental and sleep disorders (Table 5). Substance disorders were the most frequent mental disorder found in those who had a mental disorder diagnosed before a sleep disorder (49.7%) and in those who were diagnosed with a sleep disorder prior to a mental disorder (32.9%). Adjustment disorders were the most frequently diagnosed mental disorder in those who had a mental disorders and sleep disorders diagnosed at the same time (29.9%). Substance use disorders, mood disorders, anxiety disorders, PTSD/ASD, and adjustment disorders were all diagnosed most frequently before a sleep disorder. Insomnia was the most frequently diagnosed sleep disorder in all temporal groups. Sleep disordered breathing, circadian rhythm disorders, insomnia, parasomnia and hypersomnia were all diagnosed most frequently after a mental disorder.

Table 5
Temporal Sequence of Specific Mental and Sleep Disorders

Mental and Sleep Disorder Variable	Mental Disorder Diagnosed prior to Sleep Disorder n=99,382		Mental Disorder and Sleep Disorder Diagnosed at Same Time n=16,542		Sleep Disorder Diagnosed Prior to Mental Disorder n=38,397	
Mental Disorder	N	%	n	%	n	%
Substance Use Disorder	49,371	*49.7*	3,176	*19.5*	12,625	*32.9*
		75.8		***4.8***		***19.4***
Mood Disorder	12,353	*12.4*	2,712	*16.7*	5,432	*14.1*
		60.2		***13.2***		***26.5***
Anxiety Disorder	9,110	*9.2*	2,965	*18.2*	5,622	*14.6*
		51.4		***16.8***		***31.7***
PTSD/ASD	8,607	*8.7*	2,549	*15.7*	4,475	*11.7*
		55		***16.3***		***28.6***
Adjustment Disorder	19,941	*20.1*	4,855	*29.9*	10,243	*26.7*
		56.9		***13.8***		***29.2***

	Mental Disorder Diagnosed prior to Sleep Disorder n=99,382		Mental Disorder and Sleep Disorder Diagnosed at Same Time n=16,542		Sleep Disorder Diagnosed Prior to Mental Disorder n=38,397	
Sleep Disorder	n	%	n	%	n	%
Sleep Disordered Breathing	16,049	*16.1*	728	*4.5*	6,235	*16.2*
		69.7		***3.1***		***27***
Circadian Rhythm Sleep Disorders	2,108	*2.1*	244	*1.5*	1,256	*3.3*
		58.4		***6.7***		***34.8***
Insomnia	74,645	*75.1*	14,424	*88.7*	28,384	*73.9*
		63.5		***12.3***		***24.1***
Narcolepsy	-	-	-	-	-	-
		-		-		-
Parasomnia	3,298	*3.3*	780	*4.8*	1,104	*2.9*
		63.6		***15.1***		***21.3***
Hypersomnia	3,279	*3.3*	81	*0.5*	1,416	*3.7*
		68.6		***1.6***		***29.6***

Table represents column frequencies /*column percentages in italics*/***row percentages in bold italics***

Research question 5: Does a sleep disorder diagnosed prior to deployment increase the likelihood of having a mental disorder or TBI diagnosis post deployment?

For research question five, mental disorders were collapsed into the same categories as in research questions two and three, and TBI was categorized as 1 (present) and 0 (absent). Logistic regression was performed to determine the extent to which having a pre-existing sleep disorder increased the likelihood of being diagnosed with a mental disorder after deployment. The predictor variable was the presence or absence of a pre-existing sleep disorder. The outcome variable was coded as 1 for the presence of a mental disorder and 0 if there was no diagnosis of a mental disorder. The model was then adjusted for the following covariates using a forced entry method: race, grade, gender, marital status, location of the military deployment, presence of TBI, age, and average number of deployments.

A second logistic regression was performed to examine the extent to which a pre-existing sleep disorder increased the probability of a TBI occurring after deployment. The same predictor variables were used. The outcome variable (TBI) was coded as 1 for the presence of TBI and 0 for no TBI. The model was then adjusted for the following covariates using a forced entry method: race, grade, gender, marital status, location of military operation, age, and average number of deployments. Covariates included in the models were chosen based on available literature.

In the unadjusted model, participants with a pre-existing sleep disorder had lower odds of being diagnosed with a mental disorder after deployment than those without a pre-existing sleep disorder (OR: 0.89, 95% CI [0.87, 0.92], $p<0.001$). The adjusted model used a forced entry method for the following covariates: race, grade, gender, marital status, location of military operation, presence of TBI, age, and average number of deployments. In the adjusted model, participants with a pre-existing sleep disorder had higher odds of being diagnosed with a mental disorder after deployment than those without a pre-existing sleep disorder (OR: 1.13, 95% CI [1.09, 1.16], $p<0.001$).

The extent to which pre-existing sleep disorders are associated with post deployment diagnosis of TBI was examined using logistic regression. In the unadjusted model, participants with a pre-existing sleep disorder had lower odds of sustaining a TBI after deployment than those without a pre-existing sleep disorder (OR: 0.61, 95% CI [0.58, 0.63], $p<0.001$). After adjusting for the covariates (race, grade, gender, marital status, location of military operation, presence of TBI, age, and average number of deployments) participants with a pre-existing sleep disorder continued to have lower odds of sustaining a TBI after deployment than those without a pre-existing sleep disorder, but to a lesser degree (OR: 0.79, 95% CI [0.76, 0.83], $p<0.001$).

Table 6: *Prediction of Mental Disorders and TBI Based on Pre Existing Sleep Disorders*

	Mental Disorders			TBI		
Variable	Odds Ratio	95% Confidence Interval	*p* value	Odds Ratio	95% Confidence Interval	*p* value
Unadjusted Model						
Pre Existing Sleep						
Yes	0.89	(0.87,0.92)	<0.001	0.61	(0.58,0.63)	<0.001
No (referent)	-----	-----	-----	----	-----	-----
Adjusted Model						
Pre Existing Sleep						
Yes	1.13	(1.09,1.16)	<0.001	0.79	(0.76,0.83)	<0.001
No (referent)	-----	-----	-----	-----	-----	-----
Covariates						
Age	.99	(0.995,0.994)	<0.001	0.97	(1.00, 1.00)	<.0001
Average Number of Deployments	1.00	(1.00,1.00)	0.0019	1.01	(1.01,1.01)	<.0001
Race: white (referent)	-----	-----	-----	-----	-----	-----
Race: Asian/Pacific Islander	0.91	(0.92,0.91)	<0.001	0.97	(0.98,0.97)	<.0001
Race: black	0.91	(0.915,0.91)	<0.001	0.96	(0.96,0.96)	<.0001
Race: Hispanic	0.95	(0.96,0.95)	<0.001	1.00	(1.01,1.00)	0.0497
Race: other	0.95	(0.96,0.93)	<0.001	0.97	(0.98,0.95)	<.0001
Race: unknown	0.98	(0.99,0.97)	0.0027	0.97	(0.98,0.96)	<.0001

	Mental Disorders			TBI		
Variable	Odds Ratio	95% Confidence Interval	*p* value	Odds Ratio	95% Confidence Interval	*p* value
Race: American Indian/Alaskan Native	1.01	(1.02,0.99)	0.5554	0.99	(1.01,0.98)	0.3834
Grade E1-E4 (referent)	-----	-----	-----	-----	-----	-----
Grade: E5-E9	0.91	(0.91, 0.90)	<0.001	0.93	(0.93,0.93)	<0.001
Grade: O1-O5	0.75	(0.76,0.75)	<0.001	0.89	(0.90, 0.89)	<0.001
Grade: O6-O10	0.67	(0.68,0.65)	<0.001	0.89	(0.91, 0.88)	<0.001
Grade: WO1-WO5	0.83	(0.84,0.82)	<0.001	0.91	(0.92,0.89)	<0.001
Gender: Male (referent)	-----	-----	-----	-----	-----	-----
Gender: Female	1.08	(1.09,1.08)	<0.001	0.93	(0.93,0.93)	<0.001
Marital Status: Married (referent)	-----	-----	-----	-----	-----	-----
Marital Status: Other	1.06	(1.07,1.06)	<0.001	1.01	(1.01, 1.00)	0.0024
Marital Status: Single	0.96	(0.96, 0.95)	<0.001	0.97	(0.98, 0.97)	<0.001
Marital Status: Unknown	1.16	(1.23-1.09)	<0.001	0.97	(1.02,.93)	0.233
Operation: OEF (referent)	-----	-----	-----	-----	-----	-----
Operation: OIF	1.08	(1.08,1.07)	<0.001	1.04	(1.05,1.04)	<0.001
Operation: OND	0.87	(0.89,0.86)	<0.001	0.95	(0.96, 0.94)	<0.001
TBI: Absence (referent)	-----	-----	-----	-----	-----	-----
TBI: Presence	1.2	(1.207, 1.20)	<0.001	-----	-----	-----

Summary

Results from the descriptive analysis of the sample revealed that the sample was mostly young white married males, junior enlisted, and working in the logistics and ground combat elements. Insomnia, sleep disordered breathing, substance use disorders and adjustment disorders were the most frequently diagnosed disorders. The vast majority of mental disorders and sleep disorders were diagnosed after return from deployment. Participants with TBI had more insomnia and parasomnias, and there was a weak but significant association between mild TBI and sleep disordered breathing, insomnia, and parasomnia. Mental disorders preceded sleep disorder diagnoses more frequently than sleep disorder diagnoses preceded before mental disorders or both at the same time. Finally, participants with pre-existing sleep disorders were at higher risk for being diagnosed with a mental disorder after deployment than those without a sleep disorder diagnosed prior to first deployment. This was not the case for TBI even after adjustment for other covariates.

Relationship of current findings to previous findings:

Sample Characteristics & Frequency of Diagnosed Disorders

With the exception of marital status, this sample is representative of active and reserve military populations reported in Department of Defense demographic reports (U.S. Department of Defense, 2013). This study had higher representation of married service members (71.7%) than the 56.6% that were reported in 2012 Profile of the Military Community (U.S. Department of Defense, 2013). Demographic data, such as marital status, were obtained at the day of the participant's first deployment and therefore may not reflect any changes that might have occurred at the time of their first diagnosed disorder that could have been at any time during the longitudinal data set. This "snapshot" of the participant's marital status may explain some of the divergence in this sample.

Sleep Disorders

Insomnia was the most commonly reported sleep disorder (70.3%) and the number one diagnosed sleep disorder in both men (68.5%) and women (83.2%). Those with insomnia were predominately male, with an average age of 26.8 years, married (68.1%), white (62.2%), and worked most often in logistics and ground combat military occupations. Most of those with insomnia were junior (59.3%) and senior enlisted (30.8%). This study matches population estimates of insomnia and short sleep duration in active duty military members, ranging from 17-72% in those who had deployed (Gehrman et al., 2013; Luxton et al., 2011; McLay, Klam, & Volkert, 2010; Plumb, Peachey, & Zelman, 2013a), and from 24-63% in those who had been referred for specialty care for a sleep disturbance (Mysliwiec, Gill et al., 2013; Mysliwiec, McGraw, Pierce, Smith, Trapp, & Roth, 2013a). The findings are also consistent with previously reported demographics of military members with insomnia; insomnia is most often reported in Caucasian males, average age between 29-34 years, and junior enlisted (Luxton et al., 2011b; McLay et al., 2010; Mysliwiec et al., 2013; Mysliwiec, McGraw, Pierce, Smith, Trapp, & Roth, 2013b; Plumb, Peachey, & Zelman, 2013b).

Sleep disordered breathing disorders were found in 19.3% of this study's sample; 20.9% in men and 7.6% in women. The service members diagnosed with sleep disordered breathing tended to be a little older, senior enlisted (E5-E9), male, and served most frequently in the logistics occupation. The frequency of this diagnosis was lower than previous reports in the military (27.2% - 76.8%). Most previous estimates were in military members referred for specialty care for a sleep disturbance (Eliasson, Kashani, Cruz, & Vernalis, 2012; Mysliwiec et al., 2013; Mysliwiec et al., 2013a), this study is based on all available provider encounters and not just specialty care clinics, likely accounting for the different findings.

Circadian rhythm disorders were most common among those serving in the wing, junior enlisted (E1-E5) and officers (O1-O5). The negative consequences of shift work, and day and night aviation operations are well studied in the military. The findings of this study are consistent with rates reported in previous literature. (Caldwell Jr., 1997; Caldwell & Caldwell, 2005; Luna, French, & Mitcha, 1997; Caldwell, Chandler, & Hartzler, 2012; Rabinowitz, Breitbach, & Warner, 2009).

Hypersomnia was found in 3.9% of the sample. Over ninety percent (92.6%) of those with hypersomnia were male, with an average age of 31.3 years, serving most often in the logistics field. More than half (54.3%) were senior enlisted (E5-E9) and most were Caucasian (60.1%). Hypersomnia is not well studied in the military population and when it is, it usually focuses on patients with TBI. The frequencies reported here are consistent with civilian rates. An early study of hypersomnia in a civilian urban population reported hypersomnia in about 4.2% of the study sample; those with hypersomnia were relatively young (mean age 25 years) and equally distributed by gender (men - 54.8%; women - 45.2%) (Bixler, Kales, Soldatos, Kales, & Healey, 1979). Studies of hypersomnia are limited by differences in conceptual definitions and nomenclature of hypersomnia and lack of perfected measurements between subjective and objective assessments for hypersomnia (Avidan, 2012; Partinen & Hublin, 2005). These difficulties may have affected this sample but it is difficult to discern due to lack of previous reports of hypersomnia in military populations.

Parasomnias are rare and usually occur in younger adults and children (Fleetham & Fleming, 2014). In an epidemiologic study of outpatients in Hong Kong, sleep walking and REM behavior disorder was found in 2.9% and 3.8% of the sample (Lam, Fong, Ho, & Wing, 2008). Parasomnias were found in 2.9% of the current study; they were mostly male (89.9%), younger (average mean age 25.25 years), and junior enlisted (E1-E5) serving in the ground combat and logistics community. Like hypersomnia, they are not well studied in the military and veteran community and this study presents a unique opportunity to identify those at risk for both of these understudied disorders.

Mental Disorders

Substance use disorders were the most frequently diagnosed mental disorders in this sample (27.7%) which is higher than previously reported rates that range between 5-26% (Bray et al., 2010; Burnett-Zeigler et al., 2011; Erbes, Kaler, Schult, Polusny, & Arbisi, 2011; Green, Beckham, Youssef, & Elbogen, 2014; McKenzie et al., 2010; Seal et al., 2011; Wojcik, Akhtar, & Hassell, 2009). A population study of the U.S. military in 2011 places alcohol use disorders and substance use disorders at the third and fourth most frequently diagnosed mental disorders (Armed Forces Health Surveillance Center, 2012). However, McKenzie et al (2010) found substance use disorders the most frequently diagnosed mental disorder in Gulf War veterans in a study that examined temporal relationships of mental disorders only. It is not surprising that the frequencies of substance abuse disorders are higher in this sample, which is composed only of those service members diagnosed with a sleep disorder. Substance abuse causes disruptions in the sleep cycle. Alcohol in large doses causes sleep disturbances, specifically increased physiological alertness on a rising phase of its plasma concentration curve (Papineau, Roehrs, Petrucelli, Rosenthal, & Roth, 1998), dose dependent suppression of REM sleep in the first half of the night (Roehrs & Roth, 2001), and increases duration and frequency of occlusion episodes and degree of hypoxemia (Issa & Sullivan, 1982).

Those at risk for substance use disorders are men, younger age, and junior enlisted, which was confirmed by the current study (Burnett-Zeigler et al., 2011; Green et al., 2014; Jacobson et al., 2008; Seal et al., 2011). Substance use disorders were found most often in those who served the logistics and ground combat element occupations, and they were the number one diagnosed mental disorder in all military occupations, including those in the medical field. Military

members who serve in the logistics and ground combat element are more likely than their counterparts to be exposed to combat operations. The findings of this study showed that those who were married were diagnosed with substance use disorders more frequently than their divorced/single counterparts. This differs from other studies showing that substance use disorders are diagnosed more frequently in those who were without partners (Burnett-Zeigler et al., 2011; Seal et al., 2011). This may be attributed to the fact that in the current study marital status was taken from the day of the service member's first deployment, which did not reflect any changes that might have occurred over time.

Adjustment disorders were the second most commonly diagnosed mental disorder found in the sample (14.8%). Rates of adjustment disorder have been reported in as few as 1-2% of an overall deployed military sample (Crain, Larson, Highfill-Mcroy, & Schmied, 2011; Nevin, 2009) and as many as 30-40% of service members who were either evacuated from a theater of operation or hospitalized for any reason or specifically a mental disorder (Hoge et al., 2005; Rundell, 2006; Wojcik et al., 2009). The number one diagnosed mental disorder in the U.S. military, affecting 26.3% of the population between 2000 and 2011 was adjustment disorders (Armed Forces Health Surveillance Center, 2012). The aforementioned study was a surveillance of the entire military, whereas the current study is restricted to deployed service members who at some point had received a sleep disorder diagnosis. The current study used first incidence of disorders which may have contributed to the lower number of adjustment disorders. Consistent with the literature on those serving in the military, adjustment disorders were found to occur most often in younger enlisted military service members(Armed Forces Health Surveillance Center, 2013; Goodman, DeZee, Burks, Waterman, & Belmont, 2011; Wojcik et al., 2009). Adjustment disorders were found most often in men in this study that differs from the findings from previous studies where women have been shown to be more at risk for adjustment disorders, and most other mental disorders except for substance use disorders (Armed Forces Health Surveillance Center, 2013; Wojcik et al., 2009). Previous research has focused on military wide surveillance data and/or rates of those who were specifically hospitalized for mental disorders. This study is specifically using a deployed sample where only an estimated 280,000 (14%) of the over 2 million service members deployed were women (Myre, 2013).

Mood disorders, inclusive of all affective disorders, were found in 8.7% of this sample, consistent with previous findings. Mood disorders range from 8.3% to 11.8% in deployed service members (Erbes et al., 2011; Ferrier-Auerbach, Erbes, Polusny, Rath, & Sponheim, 2010; McKenzie et al., 2010; Thomas et al., 2010). Age, rank, and exposure to combat are risk factors for mood disorders (Booth-Kewley, Highfill-Mcroy, Larson, Garland, & Gaskin, 2012; Goodman et al., 2011; Luxton, Skopp, & Maguen, 2010) and in the current study mood disorders were most frequently found in those serving in the logistics field (32.4%). Diverging from previous studies, mood disorders were found overwhelmingly in males. Most studies show that mood disorders occur more frequently in women than men (Armed Forces Health Surveillance Center, 2013; Goodman et al., 2011; Luxton et al., 2010; Tanielian, 2008; Wojcik et al., 2009).

Anxiety disorders are reported in 1.27% to 11.2% of deployed military service members (Booth-Kewley et al., 2012; Curry, Aubuchon-Endsley, Brancu, Runnals, & Fairbank, 2014; Lovering, Proctor, & Heaton, 2013; McKenzie et al., 2010). Risk factors for anxiety disorders in the military consist of the following: female gender, Caucasian race, junior enlisted, and those

who had been exposed to combat (Booth-Kewley et al., 2012; Curry et al., 2014; Goodman et al., 2011; Lovering et al., 2013; Wojcik et al., 2009). The current study found anxiety disorders in 7.5% of the sample, consistent with previous findings. Anxiety disorders were found most often in men, junior enlisted, Caucasian race, and those serving in the logistics and ground combat element. With the exception of female gender, these findings are consistent with the aforementioned studies on demographic characteristics.

Post-traumatic stress disorder, ASD, and combat operational stress were found in 6.6% of the sample. Demographic characteristics of those with PTSD/ASD included being predominately white, junior enlisted, married, male, and working in the ground combat element and logistics field. Those with PTSD/ASD also had the 2nd longest average length of deployment. The frequency of PTSD/ASD in this study was on the lower end of that previously reported. Rates of PTSD in active duty and veteran populations have are reported to range from 6.5% to 20.7% (Erbes et al., 2011; Hoge et al., 2004; McKenzie et al., 2010; Phillips, Leardmann, Gumbs, & Smith, 2010; Polusny et al., 2011; Schneiderman, Braver, & Kang, 2008; Tanielian, 2008; Thomas et al., 2010). A recent meta-analysis of the research on PTSD in the military and veteran population was conducted. Weighted post-deployment rates of PTSD were 5.5% in general population samples and 13.2% in combat operational units (Kok, Herrell, Thomas, & Hoge, 2012). The higher frequency of PTSD/ASD in combat units is consistent with this study; 32.9% of participants with PTSD were found in the ground combat element and 29.2% of participants were found in the logistics occupation.

Traumatic Brain Injury

Consistent with previous research, TBI was found in 17.8% of the sample. Demographic characteristics of those with TBI included being a young male, junior enlisted, and serving in combat units which is consistent with previous research (Carlson et al., 2010; Hoge et al., 2008; Macera, Aralis, Rauh, & MacGregor, 2013; Schneiderman et al., 2008; Tanielian & Jaycox, 2008; Vanderploeg et al., 2012; Wilk et al., 2010). These finds add to current knowledge, by providing comprehensive demographic details about military members with TBI.

Comorbid Mental Disorders

The highest frequencies of comorbid mental disorders were substance use disorders and adjustment disorders (18.2%), substance use disorders and mood disorders (16.3%), anxiety disorders and adjustment disorders (15.1%), and mood and anxiety disorders (14.8%). Most studies of mental disorders in military populations focus on singular disorders such as alcohol use, PTSD, or depression. Only one other study examined comorbid mental disorders in military service members. Schmied and colleagues used personnel and medical records of 136,300 Marines who enlisted between 2002 and 2005. Compared with the findings of this study, they found slightly higher percentages of comorbid disorders. The most common comorbid disorders in their sample of Marines were anxiety (inclusive of PTSD/ASD) and mood disorders (26.3%), adjustment disorders and mood disorders (22.6%), mood and other disorders (inclusive of personality disorders) (19.9%). Outcomes in service members with comorbid disorders were worse than those with a single diagnosis. Those with comorbid disorders before deployment

were three times more likely to be discharged from the military following a deployment. They also found that hospitalizations increased with the number of psychiatric diagnoses per subject (Schmied, Highfill-McRoy, Crain, & Larson, 2013). The higher rates of comorbid disorders in the study done by Schmied could be attributable to the sample. Those in the United States Army and United States Marine Corps have higher rates of mental disorders when compared with other branch services (Baker et al., 2009). This study used all deployed military service members regardless of branch of service, which could explain the lower percentages of comorbid mental disorders.

Comorbid Sleep and Mental Disorders

This is the first study to identify all comorbid mental and sleep disorders in a deployed military sample. Only one other study addressed sleep and mental disorders in military service members. Mysliwiec and colleagues (2013a) used a sample of 725 service members who were referred for a polysomnography to identify sleep and mental disorders. Mild sleep apnea was the most frequently diagnosed sleep disorder (27.2%), followed by insomnia (24.7%). Of those with obstructive apnea, 15% had anxiety, 21% had depression, and 11% had PTSD. Of those with insomnia, 23.4% had anxiety, 31.4% had depression, and 20.7% had PTSD (Mysliwiec et al., 2013a). Substance use disorders and adjustment disorders were not addressed. The findings of the current study demonstrate that the frequency of comorbid sleep disordered breathing and anxiety, mood, and PTSD (10%, 12.8%, and 8.5% respectively) were consistent with previous results. The frequencies of comorbid insomnia and anxiety, mood, and PTSD (11.6%, 13.45%, and 10.6% respectively) were lower than that reported in Mysliwiec et al. This could be attributed to the fact that the sample in the Mysliwiec study was small (n=725) and it represented only those who were referred for a sleep study and therefore the higher rates could have been due to sampling bias.

In this study, comorbid mental and sleep disorders consisted of insomnia and substance use disorders (40.6%) and insomnia and adjustment disorders (23.8%). The discussion regarding the coexistence of substance use disorders and insomnia was presented in earlier sections. However, the unique findings in this study bring to light the significance of these comorbid diseases in deployed military service members.

Comorbid Sleep Disorders and TBI

The current study is novel in that there is no previous research using a large sample of military service members that examined comorbid sleep disorders and TBI. Insomnia was overwhelmingly the most frequently diagnosed sleep disorder in participants with TBI (83%). Sleep disordered breathing was the next most frequently diagnosed sleep disorder (8.8%), followed by parasomnias (5.3%), hypersomnia (1.6%) and circadian rhythm disorders (1.2%). When severity of TBI was included in the analysis, those with mild TBI had more insomnia and circadian rhythm disorders and those with severe TBI had more parasomnias. While the frequency of sleep disordered breathing was higher in mild TBI, they were not clinically different from the other categories of TBI severity. What is understood about sleep disturbances and TBI in the military has been gleaned from small retrospective studies using service members who had been referred for a sleep disturbance. The findings here are consistent with their

findings: insomnia occurs more frequently in service members with TBI and frequencies and percentages of sleep disordered breathing are similar between those with mild TBI and severe TBI (Capaldi, Guerrero, & Killgore, 2010; Collen, Orr, Carter, Holley, & Lettieri, 2011; Fogelberg, Hoffman, Dikmen, Temkin, & Bell, 2012).

Comorbid Mental Disorders and TBI

Percentages of comorbid mental disorders and TBI are consistent with both military and civilian studies. In previous military studies, depression in service members with TBI ranged from 0% to 66%, anxiety and TBI from 1.1% to 74%, PTSD/ASD and TBI from 0.04% to 26%, and substance use disorders and TBI was reported at 21% (Brenner, Vanderploeg, & Terrio, 2009; Carlson et al., 2011; MacGregor, Dougherty, & Galarneau, 2010; Wall, 2012). In the current study, the comorbid rate for mood disorders and TBI was 9.2%, anxiety and TBI was 9.6%, PTSD/ASD and TBI was 12.1%, and substance use disorders and TBI was 33.8%. This study adds to previous research by the addition of comorbid adjustment disorders and TBI percentages of 20.8%. Previous studies were limited to specific units, small sample sizes, and the inclusion of both active duty and veteran subjects. This study is the first to identify all mental disorders and TBI in a large sample of deployed military service members.

Temporal Sequence of Mental Disorders and Sleep Disorders

Only one other study examined the temporal sequence of disorders in deployed military population but addressed only mental disorders, making it difficult to place the findings of the current study in context (McKenzie et al., 2010). What is known about the temporal sequence of mental and sleep disorders is taken from studies performed on civilian populations. The findings in this study are consistent with Ohayon & Roth (2003) who found that insomnia is a predictor of a past psychiatric history, and with other studies where anxiety was found to precede insomnia more often than insomnia preceded anxiety (Johnson, Roth, & Breslau, 2006; Ohayon & Roth, 2003).

Previous research indicates that mood disorders most often follow insomnia (Johnson et al., 2006; Ohayon & Roth, 2003) which is inconsistent with the findings of this study. Over 60% of the mood disorders were diagnosed prior to a sleep disorder and over 26% were diagnosed after insomnia. Differences in the findings of this study and previous research could be explained by several factors. First, it is surmised that the compulsory nature of health surveillance in the military may increase the likelihood of detecting a mental disorder sooner than what would be expected in the civilian community, even in the face of potential stigma in the military. Second, in the current study, provider generated diagnoses of mental and sleep disorders were used whereas previous research used retrospective surveys of subjective reports that could have been affected by recall bias. It is also important to note that the results of the current study do not necessarily imply the sequence of symptom onset; it only provides the order in which these deployed service members are diagnosed when presenting for care.

In this study, PTSD and ASD were diagnosed most often before a sleep disorder (55%) and second most after diagnoses of a sleep disorder (28.6%). Only 16% of those with PTSD/ASD were diagnosed at the same time. Establishing the temporal emergence of sleep

disorders and PTSD is difficult in the extant literature. There is some evidence that sleep disorders, such as nightmares, insomnia, and excessive sleepiness are predictive of PTSD (van Liempt, van Zuiden, Westenberg, Super, & Vermetten, 2013). Participants who have been exposed to a traumatic event experience subjective sleep problems such as difficulty falling and staying asleep which may be attributable to noradrenergic arousal, negative reinforcement of avoidance of nightmares, and inability to use coping strategies during sleep (Babson & Feldner, 2010). Sleep problems can also persist, even after evidence-based therapy for PTSD. Zayfert and DeViva (Zayfert & De Viva, 2004) found that 48% of participants who had completed cognitive behavioral therapy for PTSD had residual insomnia. In review, sleep disorders are predictive of subsequent PTSD, sleep problems are symptoms of both disorders, and sleep disorders persist, even after treatment for the disorder. The findings of this study identify that over 70% of the diagnoses of PTSD/ASD occurred either before the sleep disorder or at the same time as a diagnosis of a sleep disorder. These outcomes are novel and will provide an opportunity to build on what is already known about the disorders in a military population. It is impossible to determine causality in this study, but the findings suggest that sleep disorders may be a consequence of PTSD/ASD in a subset of these active duty service members.

Alcohol in large doses causes sleep disturbances, specifically increased physiological alertness on the rising phase of its plasma concentration curve (Papineau et al., 1998), dose dependent suppression of REM sleep in the first half of the night (Roehrs & Roth, 2001), and increases duration and frequency of occlusion episodes and degree of hypoxemia (Issa & Sullivan, 1982). Consistent with what is known, substance use disorders were diagnosed most frequently (75%) in this sample of individuals prior to a sleep disorder. However, almost 20% of those diagnosed with substance use disorders occurred after the diagnosis of a sleep disorder. These findings may be explained by the research of Mahfoud and colleagues (2009) who found that 46% of participants who were being treated at an addiction center admitted to using substances to help them fall asleep suggesting that the sleep disorder occurred prior to the substance use.

According to the International Classification of Sleep Disorders, the cardinal feature of circadian rhythm disorders is a pattern of sleep disturbances that is attributed to changes in the circadian timekeeping system or misalignment between the internal circadian rhythms and external factors that may influence sleeping patterns (American Academy of Sleep Medicine, 2001). Circadian rhythms are generated by the suprachiasmatic nucleus of the hypothalamus which subsequently modulates daily patterns of sleep and alertness, rhythms of core body temperature, and secretion of melatonin and cortisol (Sack et al., 2007). Researchers have established that there are disturbances in the timing of melatonin rhythms in subjects with mood disorders (Lam et al., 1990; Nair, Hariharasubramanian, & Pilapil, 1984; Robillard et al., 2013) and that young adults with depression have lower salivary melatonin levels when compared with those without a diagnosis of depression (Naismith et al., 2012). Despite the evolution of evidence, there is still a question as to the directional relationship between mental disorders and circadian rhythm disturbances (Kronfeld-Schor & Einat, 2012). In the current study, circadian rhythm disorders were most often diagnosed after a mental disorder (58%). Again, it is difficult to distinguish the emergence of symptoms from these findings; however, it is evident that most of those with circadian rhythm disturbances are diagnosed after a mental disorder. This finding provides an opportunity for intervention. Emerging psychopharmacological interventions have

been designed to target the convergence between depression and circadian rhythm disorders. Agomelatine, a Melatonin 1 and Melatonin 2 agonist and 5HT2 receptor antagonist has been shown to reverse circadian rhythm disruption in those with major depression (Macisaac, Carvalho, Cha, Mansur, & McIntyre, 2014; Schmelting et al., 2014).

The mechanism underlying the pathology of mental disorders in sleep disordered breathing is believed to be a result of the activation of the hypothalamic-pituitary-adrenal (HPA) axis (Buckley & Schatzberg, 2005). Individuals with sleep disordered breathing have increased odds of developing depression (Peppard, Szklo-Coxe, Hla, & Young, 2006). Sleep disordered breathing, in this study, was diagnosed most often after a mental disorder (69.7%); a finding somewhat at odds with the Peppard et al. findings (2006). It is possible that the presentation of care for a mental disorder may have made it more likely that the service member would be screened for the presence of sleep disordered breathing and therefore would explain the inconsistencies with previous research.

Parsomnias and hypersomnia were both diagnosed predominantly after the diagnosis of a mental disorder (63.6% and 68.8% respectively). There is some evidence of the co-existence of REM sleep behavior disorder (parasomnia) and PTSD in veteran populations (Husain, Miller, & Carwile, 2001). However there is no evidence regarding the temporal sequence of both of these disorders and mental disorders in civilian or military populations. The temporal findings of these two clusters of symptoms are a novel contribution to this body of research.

Predictive Patterns of Pre-existing Sleep Disorders on the Development of Mental Disorders and TBI

It is well-established that insomnia is a predictor of the development of mental disorders (Breslau, Roth, Rosenthal, & Andreski, 1996; Taylor, Lichstein, Durrence, Reidel, & Bush, 2005). Those with a pre-existing sleep disturbance are more likely to develop a psychiatric disorder three months after a traumatic experience (Bryant, Creamer, O'Donnell, Silove, & McFarlane, 2010). Using self-report data from the Millenium Cohort Study, Gehrman and colleagues assessed the relationship between pre-existing sleep disturbances (insomnia and short sleep duration) and the development of PTSD, anxiety, and mood disorders in deployed military service members. Insomnia symptoms predicted the development of anxiety, PTSD, and depression following a military deployment. The findings of the current study extend the research of Gehrman and colleagues by determining risk of the emergence of mental disorders using a large retrospective sample of provider-generated diagnoses. Importantly, those service members with pre-existing sleep disorders had higher odds of having a mental disorder after deployment after adjustment for covariates ($p<0.001$), which correlates well with findings from the study reported herein.

Examining the impact of the diagnosis of a sleep disorder, prior to the first deployment as a risk factor for TBI in a military population, has not been well studied. The sleep-related degradation of neurocognitive performance and decreased ability to accurately discern visual environmental stimuli (Drummond, Anderson, Straus, Vogel, & Perez, 2012) in a deployed setting could possibly render a service member unable to recognize a threat in the environment (e.g., improvised explosive device) and therefore may contribute to an increased risk for injury

and TBI. Those with pre-existing sleep disorders had significantly (statistically and clinically) fewer diagnoses of TBI than those without a pre-existing sleep disorder ($p<0.001$), even after adjusting for covariates. The results of this study seem counterintuitive to the published research on the effects of sleep deprivation and road accidents. There is some evidence of a moderate risk for crashes in subjects with sleep apnea, excessive daytime sleepiness, and acute sleepiness (Zhang & Chan, 2014). However, there is no way to determine the level of sleepiness immediately proximal to the TBI in this study. Despite these limitations, and given the exposure of today's service members to occupational and combat hazards, the findings of this study add significant and clinically relevant information to the research in this area.

Effect of problems or obstacles on the results:

The problems experienced by the PI were twofold. First, the size and complexity of the three data sets were significant factors in the length of time that it took to program and analyze the data. Most of the first six months was spent organizing the data sets into a logical coherent manner suitable for analysis. The data programmers and the PI set up weekly conferences to find the best solutions to the data problems. The dissertation chair and committee vetted all major data decisions. The outcome was a product that was completed within the timeframe of the grant and successful dissertation defense of the project.

Second, one of the Research Questions centered on a comparison of those with and without pre existing mental disorders. Based on an assessment of the data, this was not possible as the data set owners combined pre existing mental disorders with all other medical diagnosis. The final product is a robust description of the mental disorders within a deployed military population that was consistent with previous studies.

Limitations:

The design of this study allows us to identify frequencies of disorders and examine relationships between those with pre-existing sleep disorders on several outcomes. However, causal inferences cannot be derived from the findings because of the nature of the design. Results of this study should be interpreted within the context of certain limitations. First, this study included only those service members with a diagnosed sleep disorder. To reduce the potential bias in this sample, only those participants who did not have a pre-existing sleep disorder prior to their first deployment were used for most statistical analyses. This study used data from available military electronic medical records. The DMSS and the DMED were designed for routine surveillance and reporting using ICD-9-CM codes to identify conditions of interest that are diagnosed in the military healthcare system. Case definitions were determined by a working group consisting of representatives from AFHSC, the Defense Centers of Excellence (DCoE) for Psychological Health and Traumatic Brain Injury, and the Office of the Assistant Secretary of Defense for Health Affairs. The quality of communication between the patient and coding provider, variation in clinical training and experience, and provider attention to detail can all contribute to the variances in data quality (Fisher et al., 1992; O'Malley et al., 2005; Schneeweiss & Avorn, 2005).

Stigma, treatment concerns, leadership issues, and practical barriers for seeking mental health care still exist in the military today (Ben-Zeev, Corrigan, Britt, & Langford, 2012; Blais &

Renshaw, 2013; Elnitsky et al., 2013; Gibbons, Migliore, Convoy, Greiner, & DeLeon, 2014; Hoge et al., 2004b; Kelley, Britt, Adler, & Bliese, 2014; Murphy, 2012; Osório, Jones, Fertout, & Greenberg, 2013; Zinzow et al., 2013). For this reason, the frequencies of mental disorders discussed in this study may underrepresent the actual disorders experienced by these military service members.

Finally, TBI coding was not standardized until after the publication of the clinical guidelines in 2009. Any data recorded prior to that date are subject to wide variation in assessment and coding by military medical personnel. Recently, it was estimated that 32,822 incident TBI's were undocumented in service members who deployed between January 2003 and November 2010 (Chase & Nevin, 2014). However, since 2009, surveillance of TBI has increased since the publication of the clinical practice guidelines. Defense and Veterans Brain Injury Centers are now located at a significant amount of major military installations (Defense and Veterans Brain Injury Center, 2014) and surveillance for the disorder has increased in frequency to multiple times during a service members career and transition into the VA (Pellerin, 2012). Because of the increased awareness observation of TBI, it is possible that service members with undiagnosed TBI may have presented for care later in their career. The data used was longitudinal in nature (spanned up to 10 years for each participant) and first ever diagnosis of TBI per participant was used to allow for maximum data captures.

Conclusion:

The findings of this study expand the work of previous researchers in the area of mental disorders, sleep disorders, and TBI in deployed military service members. The most frequent mental disorders, sleep disorders, and comorbid conditions are identified along with the emergence of disorders and the association of pre-existing sleep disorders and mental disorders after deployment. Overall, the information discovered in this study will help direct practice, assist health care providers in making treatment recommendations and reduce risk for disease, and provide critical information to guide policy regarding military readiness and suitability for future deployments. Future research is needed to identify the temporal sequence and emergence of the symptoms of disorders, identify best practices for sleep disorder treatment, and a comprehensive assessment of TBI and comorbid disorders in a military population.

Significance of Study or Project Results to Military Nursing

The findings of this study will help nursing providers target disease, make treatment recommendations and reduce risk for disease, and provide critical information to guide policy regarding military readiness and suitability for future deployments. First, the relationship between pre-existing sleep disorders and mental disorders following a deployment can help direct nursing providers in making recommendations for suitability for deployment. These findings identify an at-risk group for the development of mental disorders and the need to target prevention strategies to help reduce risk for disease. Nurses and nurse practitioners who are mandated to assess a service member within 120 days of a deployment are in a position not only to mitigate risk for future mental disabilities by providing necessary treatment for the sleep disorder, but they can help to potentially decrease the occupational burdens caused by subsequent mental disorders which include hospitalizations, involuntary separations, and disability (Hoge et al., 2005). Second, sleep disorders and their treatment may not generate the same level of stigma attached to mental disorders. Despite aggressive anti-stigma campaigns, service members continue to hold negative beliefs about treatment for mental disorders. They perceive that a mental diagnosis may be damaging to their career or that they would be perceived negatively by their peers. They feel as if they would be better off managing their own problems, and that any treatment they would receive would not be beneficial. Finally, there is a general lack of awareness about the availability of mental health care resources (Hoge et al., 2004a; Kim, Britt, Klocko, Riviere, & Adler, 2011). Directing service members into care for a sleep disorder may be more palatable to both the service member and their command element and it may prove to be a conduit for further assessment for possible comorbid mental disorders.

One of the essential findings of this study is the sequence in which service members present for care and the frequency of comorbidity of mental disorders with sleep disorders. Mental disorders are diagnosed most often before a sleep disorder, and usually, these service members present for care for substance use disorders and insomnia. Attitudes regarding substance abuse in the military have changed dramatically since the Vietnam conflict where there was little stigma attached to drug and alcohol use (Gibbs, Olmsted, Brown, & Clinton-Sherrod, 2011; McFarling, D'Angelo, Drain, Gibbs, & Olmsted, 2011; Olmsted et al., 2011). Since the start of the wars in Iraq and Afghanistan, the rate of alcohol use increased from 17% in 1998 to 25% in 2005 (Bray et al., 2010). A critical consideration to the military is that combat exposure increases the odds of substance abuse (Jacobson et al., 2008; Seal, Bertenthal, Miner, Sen, & Marmar, 2007). Today, the military has strict substance use prevention and control policies that direct aggressive media campaigns to de-glamorize substance abuse, offer encouragement of responsible use of alcohol and zero tolerance for drugs, deliver instruction to commands to enforce mandatory substance abuse assessments for service members who have reported for an alcohol or drug related incidents, and afford guidance on disciplinary actions for treatment failures (Department of the Navy, 2013). However, despite these efforts, there continues to be widespread prevalence of substance abuse and negative attitudes towards treatment. Substance use, especially drinking, continues to be an essential part of the military culture and tradition, and is used as a means of coping for deployment related and occupational issues. When service members are caught in an alcohol related incident, they feel as if they are singled out for negative attention and that treatment is considered a punitive consequence (Gibbs et al., 2011). This study identifies that deployed service members are frequently diagnosed with comorbid sleep and substance use problems and entry into the system is usually in the context of

the substance use. There is a potential for nurses to increase their observation of returning service members for both of these disorders. Identification of these problems early may help reduce risk of future mental disorders and occupational problems.

The findings related to sleep disorders and TBI offer a third opportunity to impact practice. This study provides an in depth analysis of the frequencies and types of sleep disorders that are associated with TBI. Rapid identification and treatment of sleep disorders is essential because they increase the risk for mental disorders and have the potential to seriously undermine recovery from the TBI (Mathias & Alvaro, 2012).

Changes in Clinical Practice, Leadership, Management, Education, Policy, and/or Military Doctrine that Resulted from Study or Project

None to date.

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Demographic Characteristics of the Sample

Characteristic	
Age (yrs)	28.3 (7.6σ)
Women, n (%)	35,449 (12.3 %)
Race	
White, n (%)	177,604 (61.6%)
Black, n (%)	57,604 (20%)
Hispanic or Latino, n (%)	29,005 (10.1%)
American Indian/Alaskan Native, n (%)	2,547 (0.9%)
Asian/Pacific Islander n, (%)	10,649 (3.7%)
Other, n (%)	3,842 (1.3%)
Military Service or Civilian	
Air Force, n (%)	n/a
Army, n (%)	n/a
Marine, n (%)	n/a
Navy, n (%)	n/a
Civilian, n (%)	n/a
Service Component	
Active Duty, n (%)	100%
Reserve, n (%)	n/a
National Guard, n (%)	n/a
Retired Military, n (%)	n/a
Prior Military but not Retired, n (%)	n/a
Military Dependent, n (%)	n/a
Civilian, n (%)	n/a