Research Article

Updating and Refining Prevalence Rates of Traumatic Brain Injury–Related Communication Disorders Among Post-9/11 Veterans: A Chronic Effects of Neurotrauma Consortium Study

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Purpose: To describe the prevalence of communication disorders in a cohort of 84,377 deployed post-9/11 veterans stratified by blast traumatic brain injury (TBI) exposure. Secondary aim was to evaluate the association between postconcussion symptoms, such as posttraumatic stress disorder, depression, anxiety, insomnia, pain, headache, substance use disorder, and auditory problems, among veterans with and without a communication disorder diagnosis.
Method: This is a retrospective study of the prevalence of aphasia, apraxia of speech and dysarthria, cognitive-communication disorder, fluency, and voice disorders among veterans, stratified by TBI severity and blast status. Data were obtained from the national Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn roster file provided by the Department of Veterans Affairs Office of Public Health and the Veterans Affairs' TBI screening and subsequent comprehensive TBI evaluation.
Results: Cognitive-communication disorder was the most prevalent diagnosis, comprising 57.1% of all communication disorder diagnoses, followed by voice disorder (19%) and aphasia (16%). Increased age was significantly associated with higher rates of aphasia, apraxia of speech/dysarthria, and voice disorder.
Conclusions: The current study shows that, while the overall total number of communication disorder diagnoses was higher in the blast groups than in the nonblast groups, TBI severity was a more significant risk factor for a diagnosis, with veterans in the more severe groups at a higher risk of being diagnosed with a communication disorder when compared to those with mild TBI and no blast exposure. In order to better inform rehabilitation and clinical management of communication conditions, it is critical to examine the influence of blast and postconcussive symptoms in post-9/11 veterans.

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Functional communication is vital to independence and meaningful interpersonal connection. The inability to communicate effectively has also been linked with poor social outcomes such as limited ability to form and maintain meaningful relationships (Rietdijk et al., 2013) and a satisfactory quality of life (Galski et al., 1998). Furthermore, recent economic shifts in the United States have led to an increase in the number of jobs requiring high-

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level communication skills; thus, individuals with communication disorders, which comprised roughly 5%–10% of the general population, often experience higher rates of unemployment and job instability (Ruben, 2000).

Adults with traumatic brain injury (TBI) are at risk for communication disorders (Norman et al., 2013).The U.S. Centers for Disease Control and Prevention defines TBI as “a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury.” Annually, an estimated 1.87 million emergency department visits, hospitalizations, and deaths are due to TBI (Faul et al., 2010), and around 20% of deployed veterans reported TBI exposure (Hoge et al., 2008; Lindquist et al., 2017; MacGregor et al., 2010; Schwab et al., 2007; Tanielian & Jaycox, 2008; Terrio et al., 2009). TBI can cause a cascade of neuro-anatomical change, which can affect a number of sensory systems (Giza & Hovda, 2001). As a result, impairments affecting motoric, cognitive, and linguistic systems can occur and can lead to long-term disability, high rates of unemployment, and decreased economic status; over 3 million Americans live with chronic disabilities due to TBI (Zaloshnja et al., 2008). The cognitive, motoric, and linguistic impairments often associated with TBI can have a profound impact on a person’s quality of life, occupational outlook, and social life (Galski et al., 1998; Meulenbroek et al., 2016)

The effects of TBI on brain functioning are extensive, and multiple sites of insult and mechanisms of injury can occur. Blast-related TBI is the most prevalent mechanism of injury for post-9/11 deployed veterans, often occurring from explosive devices (Mendez et al., 2013; Sayer et al., 2008) Blast injuries can be primary (e.g., when the blast wave impacts the body), secondary (e.g., penetrating wounds caused by flying debris), tertiary (e.g., direct impact trauma from sudden acceleration of the body), or quaternary (e.g., burns, chemical exposure, breathing toxic gases or vapors; Cernak & Noble-Haeusslein, 2010; Mernoff & Correia, 2010). In comparison to other types of mechanisms of injury, post-9/11 veterans who have sustained blast injuries are at high risk for acquiring communication disorders (Dion et al., 2013; Norman et al., 2013; Riley et al., 2019; Swan et al., 2017). Due to the various mechanisms of injury contributing to TBI, the effects on an individual’s communication skills are highly variable. Communication disorders associated with TBI are dysarthria, apraxia of speech, stuttering, aphasia, voice, cognitive-communication, social communication disorders, and hearing loss (Norman et al., 2013, 2018; Swan et al., 2017). The propensity for multifocal and widespread neurological damage caused by TBI and the heterogeneity of individual’s clinical presentations differentiate the deficits faced by these individuals from those experiencing communication disorders from more focal acquired and degenerative neurological disorders (Snow et al., 1998). The communicative characteristics of an individual with TBI do not fit into an easy-to-define profile as do communicative characteristics of other disorders, making diagnosis and treatment of communication disorders related to TBI challenging as they often require clinicians to employ an individualized approach.

The current study focused on describing communication disorders known to occur in post-9/11 veterans: aphasia, apraxia of speech, dysarthria, fluency, and voice and cognitive-communication disorders. Aphasia occurs after damage to the left hemisphere, resulting in a language disorder characterized by deficits in auditory comprehension, word-finding skills, reading, and writing (Gillam et al., 2011). Apraxia of speech is a programming disorder characterized by inconsistencies in speech production, which affect overall speech intelligibility and prosody (McHenry & Wilson, 1994). Dysarthria is classified as a motor speech disorder resulting from muscle weakness (Gillam et al., 2011). Stuttering is a fluency disorder characterized by an abnormally high frequency of prolongations, repetitions, and/or blockages during speech production (Van Borsel, 2014). An individual with a voice disorder demonstrates voice that is nonfunctional, that is, “does not work, perform or sound as it normally should and interferes with communication” (Roy et al., 2005). *Cognitive-communication disorders* are defined as “difficulty with any aspect of communication that is affected by disruption of cognition” (American Speech-Language-Hearing Association, 2005). To our knowledge, our study is the first large-scale study to identify cognitive-communication disorder in post-9/11 veterans. De Riesthal (2009) provided general demographic data concerning veterans with mild TBI (mTBI) related to blast and reviewed the literature of current evidence-based treatment approaches for cognitive-communication disorders; however, this study was descriptive in nature and did not allow specifics to be drawn regarding prevalence rates and risk factors for communication disorders related to TBI or blast-related TBI for post-9/11 veterans. In addition to identifying this disorder, our study aimed to describe the relationship between this disorder and the mechanism of injury and severity in a cohort of veterans who had TBI using data from an in-person comprehensive medical TBI evaluation in the VA system of care.

In addition to the communication and cognitive deficits associated with TBI, it is important to note that, in post-9/11 veterans, there are often underlying concomitant conditions that contribute to complex clinical presentations and can have a significant impact on recovery and clinical management of symptoms (Pugh et al., 2019; Sayer et al., 2008). Research has identified high rates of posttraumatic stress disorder (PTSD), depression, anxiety, insomnia, pain, headache, substance use disorder, auditory problems, and communication disorders in post-9/11 veterans with TBI (Dolan et al., 2012; Norman et al., 2018; Riley et al., 2019; Swan et al., 2017). In addition, deployment-related TBI, in particular, has been linked to higher incidences of negative health and behavioral outcomes, when compared to non–deployment-related TBI (Martindale et al., 2018). These concomitant disorders likely have an effect on the presence and severity of communication disorders. Increased symptoms of anxiety, depression, and PTSD and higher incidences of alcohol consumption have been found in post-911 veterans (Norman et al., 2018; Riley et al., 2019). Iraq and Afghanistan post-9/11 veterans with comorbid TBI and PTSD have a greater probability of developing acquired stuttering, and the use of central nervous system–acting medications to manage these symptoms has also been linked to stuttering (Norman et al., 2018). Veterans with comorbid TBI, PTSD, and depression are also at a higher risk for auditory dysfunction, such as hearing loss, tinnitus, or both (Swan et al., 2017). The various concomitant disorders veterans experience post-TBI are complex in nature and must be fully addressed and taken into consideration for overall effective diagnosis and successful therapeutic rehabilitation.

The purpose of the current study was to determine the current prevalence rates of communication disorders in a cohort of U.S. veterans deployed post-9/11, stratified by TBI severity and blast status. We focus on the prevalence of five distinct communication-based disorders: aphasia, apraxia of speech/dysarthria, stuttering, cognitive-communication disorders, and voice disorders in veterans of Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn who received health care in the Department of Veterans Affairs (VA), Veterans Health Administration who sustained a TBI, categorized by severity of injury (mild, moderate, severe, and penetrating) using the Department of Defense/VA's definition of TBI (U.S. Department of Veterans Affairs, 2016). These communication disorders were selected based on previous work identifying them as being significant in the target population (Norman et al., 2013). Our second aim was to investigate the association between postdeployment-related symptoms such as PTSD, depression, anxiety, insomnia, pain, headache, substance use disorder, auditory problems, and the selected communication disorders in veterans with TBI. A third aim was to estimate the association between communication disorder diagnosis and TBI severity and blast history after controlling for common postconcussive comorbidities and sociodemographic covariates.

Method

Sample

Following local institutional review board approval, we selected post-9/11 veterans using the national Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn roster file provided by the VA Office of Public Health and gathered data from the national VA inpatient and outpatient data files from the Austin Data Repository. Information from TBI screening and comprehensive TBI evaluation (CTBIE) data sets from the Office of Patient Care Services were also included. All individuals included in the study sample had incurred a deployment-related TBI that was initially self-reported on the VA screener and later confirmed by a medical provider on the CTBIE using the individuals' responses to detailed questions related to the event, such as duration or loss of consciousness for deployment-related TBI. TBI exposure is defined as a self-report of TBI on the VA TBI screening tool (see Figure 1).

Procedure

The VA instituted mandatory TBI screening for post-9/11 veterans entering VA care in 2007. Each veteran who reports exposure to one or more injury events (e.g., blast, vehicular accident), and endorsement of a disruption of memory or consciousness, followed by new or worsening symptoms within a week of exposure, and who reports continued symptoms in the previous week is considered to screen positively for TBI. Those individuals are then referred to a specialist for a more in-depth clinical interview, the CTBIE, which documents the type and severity of deployment-related experiences and injuries as well as current neurobehavioral symptoms. The median time between screening and the completion of the CTBIE is 16 days. Inclusion criteria for the current study followed criteria for the parent study, the Chronic Effects of Neurotrauma Consortium (CENC) Study. The purpose of the CENC is to identify phenotype trajectories of comorbidity in post-9/11 deployed veterans with no TBI and different levels of TBI severity. The inclusion criteria of the study were as follows: (a) Veteran received VA care between fiscal years 2002 and 2014 and (b) had at least 3 years of care during that period, with (c) one or more years of that care after 2007 when TBI screening became mandatory at the VA. This existing cohort allows inclusion of those individuals injured early in the wars and includes the majority of individuals with TBI and amputation injuries.

In order to best explore the associations between TBI and blast exposure, we further restricted the sample of post-9/11 veterans who had completed the CTBIE. The inclusion of the years of care and specific time period of care allowed the study team to include individuals with ample Veterans Health Administration data in order to be able to identify the communication disorders of interest. Exclusion criteria included individuals with (a) no TBI, (b) unclassified TBI, (c) initial screen but no other indication of TBI, and (d) missing injury blast variable. Individuals with potential predeployment TBI and comorbid conditions prior to their TBI were not excluded from the study.

Measures

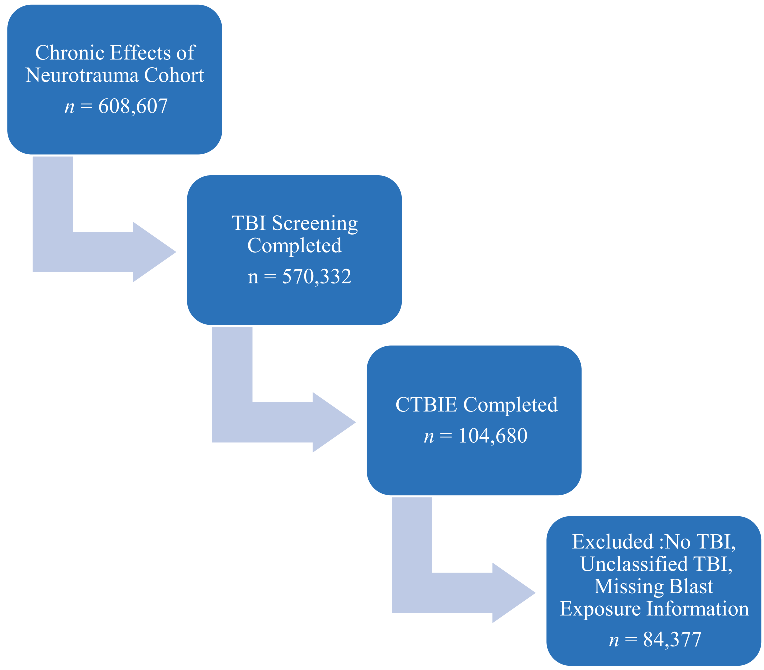
Communication Disorders

This study sought to examine prevalence and associations that pertain to the following communication-related disorders: aphasia, apraxia of speech/dysarthria, fluency, voice disorder, and cognitive-communication disorder. International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic codes (see Table 1) were used to identify veterans with these conditions as primary or secondary diagnoses in at least two separate VA health care visits at least 7 days apart.

TBI Severity and Blast History

Because the data set was limited to those who had completed the CTBIE, the entire sample was limited to those who had had some type of TBI exposure. As such,

Figure 1. Flowchart for inclusion/exclusion criteria for study sample.



the resultant TBI severities examined were (a) mTBI or (b) moderate/severe TBI (hereafter, "more severe TBI"), based on the veteran's responses to the most severe loss of consciousness, posttraumatic amnesia, and alteration of consciousness embedded in the CTBIE (U.S. Department of Veterans Affairs, 2016). Next, blast exposure was noted when the veteran positively indicated any exposure to blast during the most recent deployment (hereafter, "no blast history" or "blast history"). To examine their combined influence, a combination variable was constructed, with the following levels: (a) mTBI with no blast history, (b) mTBI with blast history, (c) more severe TBI with no blast history, and (d) more severe TBI with blast history.

Common Postconcussive Comorbidities

We identified conditions commonly subsequent to TBI and/or deployment using algorithms validated for use with International Classification of Diseases, Ninth Revision,

Table 1. International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes by condition.

Condition	ICD-9-CM code(s)
Communication disorders	
Aphasia	784.3, 484.69
Apraxia of speech/dysarthria	784.51
Fluency	370.0, 784.52
Voice disorder	784.40, 784.41, 784.49, V41.4
Cognitive-communication disorder	799.52
Posttraumatic stress disorder	309.81
Depression	296.2x, 296.3x, 311
Anxiety	300.0x, 300.2x, 300.3
Auditory dysfunction	388.11, 388.3x, 388.9, 389.0x, 389.1x, 389.2x
Insomnia	327.0x, 780.51, 780.52
Neck and back pain	720.0, 721.0, 721.3, 721.4, 721.5, 721.6,721.7, 721.8,721.9,721.91, 722.0, 722.2, 722.3,722.5, 722.7, 722.71, 722.72, 722.73, 722.80, 722.81, 722.82, 722.83, 722.90, 722.91, 722.92,722.93, 724, 723.x, 805.0, 805.1, 839.0x, 839.1x
Headache	307.81, 339.xx, 346.xx, 784.0
Substance use disorder	291.xx, 292.xx, 303.x, 304.x, 305.0, 305.2, 305.3, 305.4, 305.5, 305.6, 305.7, 305.8, 305.9

Clinical Modification diagnosis codes. Comorbidities included in this analysis are PTSD, depression, anxiety, auditory dysfunction (e.g., hearing loss and tinnitus), insomnia, neck and back pain, other pain (e.g., musculoskeletal), headache, and substance use disorder because of their common affiliations with postdeployment complaints among veterans, which require one inpatient diagnosis or two outpatient diagnoses at least 7 days apart.

Selim Physical Health Comorbidity Index

To further account for the influence of multimorbidity, we included an established algorithm for physical health comorbidities (hereafter, "Selim physical health comorbidity index"). Developed among veterans, this index identifies 30 of the most common physical health problems reported in ambulatory care and has been used in related samples and clinical settings. The resultant data indicated whether the veterans had (a) no physical health comorbidities (none), (b) one physical health comorbidity, or (c) two or more physical health comorbidities.

Sociodemographic Covariates

The roster file was supplemented with VA patient data as it was the most recent and addressed sociodemographic information that may have been missing. Demographic variables included age at the time of the TBI screening, sex, and race/ethnicity (White, Black, Hispanic, and other). Age violated the assumption of linearity in the statistical model and was therefore categorized into the following age groups: 19–29 years, 30–39 years, and 40 years and older. Military characteristics included components of armed forces (active or other), rank at discharge (enlisted or other), and branch (Army or other).

Analysis

First, we presented the characteristics of post-9/11 veterans by communication disorder status (i.e., no speech/language disorder, aphasia, apraxia of speech/dysarthria, stuttering, voice disorder, or cognitive-communication disorder). Next, we evaluated bivariate associations among each of the communication disorders relative to those in the no speech/language disorder on each of the measures in this analysis using the chi-square test statistic. Finally, we then conducted a series of logistic regression analyses, each predicting communication disorder status relative to the no speech/language disorder group to evaluate the influence of TBI severity and blast history while controlling for common postconcussive conditions, physical health comorbidities, and sociodemographic characteristics. To determine statistical significance, we compared adjusted odds ratios with their associated 95% confidence intervals as statistical significance was set to the $p < .05$ level. Although significant differences can be present when confidence intervals overlap, we used a conservative approach and identified significant differences as those conditions for which no overlap occurred. All analyses were conducted using SAS Version 9.2 (SAS Institute).

Results

Sample Characteristics

Of the 84,377 veterans who met the inclusion criteria, 94% were male, 66.6% were active duty, 73% identified the Army as their branch of service, 97% of the sample was enlisted rank, and the majority of the sample was of White race/ethnicity (69%). As shown in Table 2, 3% of the resultant sample had a diagnosis of a communication disorder in VA care. Cognitive-communication disorder was the most prevalent diagnosis, comprising approximately 57% of all communication diagnoses, followed by voice disorder (19%) and aphasia (16%).

Table 3 demonstrates that nearly 70% of the cohort reported that their TBI was blast related and more than 85% reported TBI that is mild in severity. Overall, postconcussive comorbidities were also common, namely, PTSD (81%), auditory problems (32%), depression (56%), anxiety (34%), insomnia (28%), neck and back pain (64%), other pain (50%), and substance use disorder (34%), among the sample more broadly. Based on the Selim physical health comorbidity index, more than 50% of the cohort had at least one qualifying physical health problem diagnosed in VA care.

Communication Disorders by TBI Severity and Blast History

Table 3 evaluates bivariate associations among communication disorder status by each of the covariates in the model, while Table 4 presents the results from the fully adjusted logistic regression analyses. Veterans with more severe TBI had greater odds for aphasia and cognitive-communication disorder relative to veterans with mTBI and no blast history, when controlling for sociodemographics and comorbidities.

Discussion

The current study aimed to refine and update communication disorder prevalence rates for post-9/11 veterans in the VA system of care and with a significant history of TBI, with or without blast exposure, as well as shed light on the unique relationship between communication disorders and common postdeployment conditions. Previous research by this study team identified that communication disorders are a risk factor for veterans with TBI; the current study expands and refines those findings by elucidating the relationship between communication disorders and TBI severity and blast exposure via results of a validated in-person assessment (the CTBIE). Furthermore, to our knowledge, our study is the first large-scale study to introduce the blast variable into the VA communication disorder literature and to include cognitive-communication disorder as a dependent variable in examining a cohort of veterans with confirmed TBI. The current study found that both blast exposure and TBI severity were significantly associated with the communication disorders examined:

Table 2. Sociodemographic characteristics of the 84,377 post-9/11 veterans in this sample by each of the communication disorders examined in this study.

Variable	No speech/language disorder	Aphasia	Apraxia/ dysarthria	Fluency	Voice disorder	Cognitive-communication disorder
n (%)	81,948 (97.0)	385 (0.50)	59 (0.07)	130 (0.20)	467 (0.56)	1,388 (1.64)
Age (years)						
19–29	44,122 (53.84)	186 (25.45)	19 (32.20)	58 (44.62)	173 (37.04)	613 (44.16)
30–39	22,941 (27.99)	101 (26.23)	21 (35.59)	43 (33.08)	135 (28.91)	452 (32.56)
40 and older	14,885 (18.16)	98 (48.31)*	19 (32.20)*	29 (22.31)	159 (34.05)*	323 (23.27)
Sex						
Male	77,421 (94.48)	363 (94.29)	< 95%[a]	< 99%[a]	435 (93.15)	1,287 (92.72)
Female	4,527 (5.52)	22 (5.71)	< 10%[a]	< 5%[a]	32 (6.85)	101 (7.28)*
Race/ethnicity						
White	56,958 (69.51)	278 (72.21)	36 (61.02)	85 (65.38)	282 (60.39)	951 (68.52)
African American	10,847 (13.24)	38 (9.87)	< 17%[a]	25 (19.23)	98 (20.99)*	184 (13.26)
Hispanic	10,398 (12.69)	45 (11.69)	14 (23.73)*	< 15%[a]	67 (14.35)	171 (12.32)
Other	3,745 (4.57)	24 (6.23)	< 2%[a]	< 5%	20 (4.28)	82 (5.91)
Rank						
Enlisted	79,324 (96.80)	372 (96.62)	< 95%[a]	< 98%[a]	449 (96.15)	1,334 (96.11)
Other	2,624 (3.20)	13 (3.38)	< 10%[a]	< 5%[a]	18 (3.85)	54 (3.89)
Component						
Active duty	54,643 (66.68)	259 (67.27)	39 (66.10)	88 (67.69)	244 (52.25)	913 (65.78)
Other	27,305 (33.32)	126 (32.73)	20 (33.90)	42 (32.31)	223 (47.75)*	475 (34.22)
Branch						
Army	59,726 (72.88)	282 (73.25)	37 (62.71)	94 (72.31)	367 (78.59)	1,013 (72.98)
Other	22,222 (27.12)	103 (26.75)	22 (37.29)	36 (27.69)	100 (21.41)*	375 (27.02)

[a]Based on Department of Veterans Affairs reporting guidelines; groups of 11 or fewer are not presented.
*Statistically significant at the $p < .05$ level based on chi-square analysis relative to the no speech/language disorder group.

aphasia, apraxia of speech/dysarthria, fluency, and voice and cognitive-communication disorder. The following discussion of our findings demonstrates that our study both confirms previous findings for this population and expands our understanding of the downstream effects of TBI on the communication system. Our discussion of these findings is organized by the variables with the most widespread impact and those most likely to have a significant clinical implication for providers and the health care system as a whole.

Blast Injury

A major contribution to the current knowledge base about communication disorders in post-9/11 veterans is the inclusion of the blast variable in the analysis. The current study shows that, while the overall total number of communication disorder diagnoses was higher in the blast groups than in the nonblast groups, our logistic regression results indicated that TBI severity was a more significant risk factor for a diagnosis, with veterans in the more severe groups at a higher risk of being diagnosed with a communication disorder when compared to those with mTBI and no blast exposure. Our analysis indicated no significant differences between mTBI with blast history and without blast history. While there was a significant difference for those with more severe TBI with and without blast, there did not appear to be significant differences between those more/severe groups, based on blast status. This finding was particularly true for aphasia, cognitive-communication disorder, and fluency categories and is consistent with the existent literature on communication disorders in the moderate-to-severe TBI population. Our blast results are also consistent with neuropsychological literature; both Sayer et al. (2008) and Belanger et al. (2009) found that severity of injury was a stronger predictor of cognitive and motor impairment after injury.

Our study design allows clinicians and researchers to better understand the influence of mechanism of injury and severity in order to inform and guide subsequent management and care for these disorders. Although results from our study suggest that TBI severity may be a more significant driving factor in the manifestation of communication disorders post-TBI, it is clinically relevant to acknowledge that, among those with a communication disorder in our large sample, the prevalence of those with exposure to blast was higher than those without that exposure. Therefore, although the influence of the blast may not prove to be as impactful as the overall severity of the injury, it is likely that it will have a larger breadth. It is imperative that speech-language pathologists (SLPs) and other providers working with veterans and service members with blast-related injuries understand this unique mechanism in order to target rehabilitation efforts in methods that might diverge from civilian injury mechanisms such as car accidents or sport injuries.

Cognitive-Communication Disorders

One of the most important findings in the study is that the majority of individuals with a communication disorder

Table 3. Communication disorders by traumatic brain injury severity and blast history and other comorbidities examined in this analysis.

Variable	*n* (%)	No speech/language disorder	Aphasia	Apraxia/ dysarthria	Fluency	Voice disorder	Cognitive-communication disorder
	84,377	81,948 (97.0)	385 (0.50)	59 (0.07)	130 (0.20)	467 (0.56)	1,388 (1.64)
TBI severity and blast history							
mTBI with no blast history	15,509 (18.4)	15,139 (18.47)	44 (11.43)	13 (22.03)	< 15%[a]	98 (20.99)	215 (15.49)
mTBI with blast history	56,588 (67.1)	55,089 (67.22)	223 (57.92)*	29 (49.15)*	82 (63.08)	300 (64.24)	865 (62.32)
More severe TBI with no blast history	9,682 (11.5)	9,286 (11.33)	88 (22.86)*	< 20%[a]	24 (18.46)*	51 (10.92)	233 (16.79)*
More severe TBI with blast history	2,557 (3)	2,434 (2.97)	30 (7.79)*	< 15%[a]	< 10%[a]	18 (3.85)	75 (5.40)*
Posttraumatic stress disorder							
No	16,081 (19.1)	15,838 (19.33)	38 (9.87)	17 (28.81)	15 (11.54)	64 (13.70)	109 (7.85)
Yes	68,296 (80.9)	66,110 (80.67)	347 (90.13)*	42 (71.19)	115 (88.46)*	403 (86.30)*	1,279 (92.15)*
Depression							
No	37,197 (44.1)	36,431 (44.46)	127 (32.99)	24 (40.68)	43 (33.08)	146 (31.26)	426 (30.69)
Yes	47,180 (55.9)	45,517 (55.54)	258 (67.01)*	35 (59.32)	87 (66.92)*	321 (68.74)*	962 (69.31)*
Anxiety							
No	55,570 (65.9)	54,176 (66.11)	228 (59.22)	42 (71.19)	70 (53.85)	259 (55.46)	795 (57.28)
Yes	28,807 (34.1)	27,772 (33.89)	157 (40.78)*	17 (28.81)	60 (46.15)*	208 (44.54)*	593 (42.72)*
Auditory dysfunction							
No	57,069 (67.6)	55,701 (67.97)	229 (59.48)	40 (67.80)	74 (56.92)	258 (55.25)	767 (55.26)
Yes	27,308 (32.4)	26,247 (32.03)	156 (40.52)*	19 (32.20)	56 (43.08)*	209 (44.75)*	621 (44.74)*
Insomnia							
No	60,662 (71.9)	59,157 (72.19)	254 (65.97)	40 (67.80)	89 (68.46)	299 (64.03)	823 (59.29)
Yes	23,715 (28.1)	22,791 (27.81)	131 (34.03)*	19 (32.20)	41 (31.54)	168 (35.97)*	565 (40.71)*
Neck and back pain							
No	30,430 (36.1)	29,817 (36.39)	107 (27.79)	19 (32.20)	40 (30.77)	106 (22.70)	341 (24.57)
Yes	53,947 (63.9)	52,131 (63.61)	278 (72.21)*	40 (67.80)	90 (69.23)	361 (77.30)*	1,047 (75.43)*
Other pain							
No	42,483 (50.3)	41,611 (50.78)	149 (38.70)	23 (38.98)	54 (41.54)	154 (32.98)	492 (35.45)
Yes	41,894 (49.7)	40,337 (49.22)	236 (61.30)*	36 (61.02)	76 (58.46)*	313 (67.02)*	896 (64.55)*
Headache							
No	43,133 (51.1)	42,337 (51.66)	127 (32.99)	29 (49.15)	43 (33.08)	205 (43.90)	392 (28.24)
Yes	41,244 (48.9)	39,611 (48.34)	258 (67.01)*	30 (50.85)	87 (66.92)*	262 (56.10)*	996 (71.76)*
Substance use disorder							
No	56,136 (66.5)	54,554 (66.57)	234 (60.78)	36 (61.02)	84 (64.62)	305 (65.31)	923 (66.50)
Yes	28,241 (33.5)	27,394 (33.43)	151 (39.22)*	23 (38.98)	46 (35.38)	162 (34.69)	465 (33.50)
Selim comorbidity index							
None	41,370 (49.0)	40,503 (49.43)	156 (40.52)	20 (33.90)	59 (45.38)	156 (33.40)	616 (44.38)
One	29,873 (35.4)	29,031 (35.43)	128 (33.25)	22 (37.29)	40 (30.77)	168 (35.97)	484 (34.87)
Two or more	13,095 (15.5)	12,414 (15.15)	202 (26.23)*	17 (28.81)*	31 (23.85)*	143 (30.62)*	288 (20.75)*

Note. TBI = traumatic brain injury; mTBI = mild traumatic brain injury.

[a]Based on Department of Veterans Affairs reporting guidelines; groups of 11 or fewer are not presented. *Statistically significant at the $p < .05$ level based on chi-square analysis relative to the no speech/language disorder group.

Table 4. Logistic regression results estimating the association between communication disorder diagnosis and traumatic brain injury severity and blast history after controlling for common postconcussive comorbidities and sociodemographic covariates.

	Communication disorder				
	Aphasia	Apraxia/dysarthria	Fluency	Voice disorder	Cognitive communication disorder
TBI severity and blast history	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
mTBI with no blast history	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
mTBI with blast history	1.34 (0.96, 1.87)	0.83 (0.42, 1.64)	1.29 (0.76, 2.21)	0.93 (0.73, 1.17)	1.07 (0.91, 1.24)
More severe TBI with no blast history	3.88* (2.43, 6.19)	3.63* (1.50, 8.80)	2.35 (0.97, 5.67)	1.11 (0.67, 1.85)	1.96* (1.50, 2.56)
More severe TBI with blast history	2.74* (1.89, 3.98)	1.52 (0.63, 3.67)	1.99* (1.05, 3.76)	0.84 (0.60, 1.19)	1.46* (1.20, 1.76)

Note. TBI = traumatic brain injury; AOR = adjusted odds ratio; CI = confidence interval; mTBI = mild traumatic brain injury; Ref = reference group.

*Statistically significant at the $p < .05$ level based on logistic regression analyses adjusted for common postconcussive comorbidities, the Selim physical health comorbidity index, and sociodemographic covariates.

in the sample were diagnosed with cognitive-communication disorder. This finding is not surprising, as this type of disorder, defined "as any difficulty with communication as a result of cognitive impairment" (American Speech-Language-Hearing Association, 2005), is common after TBI and has been well documented in the moderate-to-severe TBI civilian literature over several decades (Coelho et al., 1996, 2005; Krug & Turkstra, 2015; MacDonald, 2016; MacDonald & Johnson, 2005; Parrish et al., 2009). The cognitive-communication diagnosis code was not included in Norman et al. (2013), the initial study of communication disorders in this population, as that study strictly focused on more focal expressive communication disorders.

Not surprisingly, our study found that cognitive-communication disorders were the most prevalent diagnosis in post-9/11 veterans who had incurred mTBI + blast; however, this number should be interpreted with caution as most of our study participants formed a part of this injury category. Our findings also indicated the following factors were also significantly associated with cognitive-communication disorder: severity of injury (mild vs. more severe), mental health, pain, sensory, sleep or substance disturbances, and two or more comorbidities co-occurring. These factors are important to consider because cognitive-communication disorder, unlike other focal (e.g., aphasia) or organic (e.g., voice disorder) communication disorders, is a condition directly dependent on an intact cognitive system. Cognitive performance, in turn, is highly sensitive to changes in physical or mental state or mood (Belanger et al., 2010; Vanderploeg et al., 2005).

Voice

Consistent with previous research (Cornis-Pop et al., 2012; Norman et al., 2013), voice disorder was a highly prevalent diagnosis among those veterans diagnosed with a communication disorder in the study cohort. The current study showed that the majority (85%) of veterans with voice disorders had mTBI; however, using our analysis enabled stratification of this sample of veterans by the blast variable. While there were more veterans with voice disorders in the mTBI with blast history group, results of our logistic regression did not find significantly greater odds for voice disorder in veterans with a blast injury compared to those without. The strong association between voice disorder and postconcussive comorbidities (with the exception of substance use) cannot be understated. While the etiology of voice disorders in the post-9/11 veteran population can certainly be attributed to the increase in neck and head injuries (Cherney et al., 2010) in the current war conflicts, it is likely that a large proportion of voice disorder in this population are more significantly influenced by mood, pain, and sensory disorders (Rosen et al., 1998) rather than by TBI diagnoses. This finding is also consistent with Norman et al. (2013), in which over 80% of voice cases were in the "no history of TBI" category. Veterans in the older age bracket (40 years and older) and of African American race were also significantly more likely to be diagnosed with voice disorder, and this finding is also consistent with previous literature (Norman et al., 2013).

Aphasia

In our analysis, aphasia was the third most prominent diagnosis. Results from the current study diverged slightly from our earlier study in regard to the severity of TBI associated with the majority of aphasia cases. While in the previous study the majority (41%) of aphasia diagnoses in the sample were associated with TBI of moderate severity, in the current study, the majority (58%) of veterans diagnosed with aphasia in the current sample also reported mTBI with blast history. This divergence can possibly be attributed to the more precise and accurate diagnostic method employed in the current study; while the previous study simply used the presence or absence of Department of Defense TBI codes, the current study, in its use of the CTBIE as inclusion criteria, potentially yielded a more rigorous methodology and, thus, aphasia codes can be attributed to the more accurate TBI category. Furthermore, it is worthwhile to note that, in previous research (Norman et al., 2013), the aphasia diagnostic code was found to be potentially problematic when used within the context of a TBI diagnosis; focal language problems (e.g., frank naming or auditory comprehension problems) are quite rare after TBI, and it is possible that the aphasia diagnosis code might have been selected by a provider when cognitive-communication disorder might have been more appropriate to describe language problems that occur after mTBI. Because the current study included both of these diagnostic codes, the accuracy of the prevalence rates of these disorders in this cohort can be considered to be more reliable.

Demographics

In the current study, increased age was associated with an increased risk for all communication disorders with the exception of fluency and cognitive-communication disorder, and this finding is consistent with existing research. Factors such as age-related word-finding difficulties and changes in laryngeal and pharyngeal muscle strength can possibly contribute to this increased association. Sex was found to be significantly associated with cognitive-communication disorder, and this observation is consistent with current research concerning effects of mTBI on women. A meta-analysis of long-term TBI outcomes confirmed that women are at a greater risk of chronic symptomatology when compared to their male counterparts (Farace & Alves, 2000). Studies have also shown that women with mTBI are at risk for long-term postconcussive symptoms (Norman et al., 2016). These chronic symptoms often include cognitive symptoms known to contribute to communication problems and lead to subsequent cognitive-communication disorder diagnosis.

Findings regarding race and ethnicity and their association with communication disorders potentially illustrate differences in diagnostic patterns for individuals belonging to minority populations. In the current study, Hispanic race was significantly associated with a diagnosis of apraxia of speech/dysarthria, a motor speech disorder. This finding could potentially illustrate challenges in assessment of motor speech function in veterans who are possibly native speakers of languages aside from English. Speech patterns observed by clinical personnel may be reflective of an observation of dialectal differences and not necessarily a motor speech disorder. Centeno (2009) found that SLP providers reported multiple barriers to adequate assessment of speech and language disorders in minority adults. These barriers include limited assessments, a lack of linguistic knowledge, and little professional preparation related to the influence of a second language, which, in this sample, could potentially be Spanish. Along the same line, voice disorder was found to be associated with African American race, other component, and other branch of service. While findings in the general population demonstrate an increased risk for voice disorders in females and in older adults, these risks were not statistically significant in the current study sample (Roy et al., 2005). Additional relevant risk factors such as voice patterns and demands, history of upper respiratory conditions, and exposure to chemicals are beyond the scope of the current study.

Postdeployment Conditions

Results from this study confirm the need for clinicians to continue to acknowledge the multimorbidity of this population; indeed, every communication disorder analyzed in this study was significantly associated with a postconcussive symptom. Furthermore, for all of the communication disorders analyzed, the presence of two or more conditions in the comorbidity index was significantly associated with the presence of a communication disorder. Evaluating and treating communication disorders without considering concomitant mental health, sensory, pain, and other postconcussive symptoms is simply not an option for clinicians working in this field of work. Treatment in this area and functional activities related to these disorders require a holistic approach, ideally within an interdisciplinary team setting. SLPs working with these populations will need to be mindful of the potential for mental health diagnoses such as PTSD, depression, and anxiety to have a significant impact on the presence of a disorder, the management of symptoms, and the response to subsequent treatment. Cross-training with social workers, psychologists, and other mental health professionals is necessary in order to better understand and effectively treat communication disorders that co-exist with PTSD, anxiety, depression, and pain. The use of techniques such as motivational interviewing and goal attainment scaling and techniques rooted in psychology but more recently adopted by SLPs are reinforced by the findings of this study. Our study affirms the importance of SLPs being trained in not only how to identify and address communication disorders but also how to instill and evoke behavior change in order to successfully manage these disorders. Using a holistic, interdisciplinary approach, communication disorders can be identified earlier not only by SLPs but also any other medical and allied health professionals (physiatrists, psychologists, physical therapists, social workers, etc.). If communication disorders are found and referrals are made to SLPs, these same team members can collaborate in the management of these disorders, including reinforcement of communication and cognition goals outside the speech-language pathology therapy clinic and possible cotreatment of cognitive and communication symptoms with other disorders. Treating communication disorders prior to or in conjunction with mental health disorders could potentially assist veterans in achieving greater rates of success and adherence to evidence-based mental health treatments provided by the VA or community-based mental health providers. Successful management of communication disorders, such as cognitive-communication disorders, could potentially aid veterans in individual and group therapies that are highly dependent on communication abilities, for example, prolonged exposure therapy or written exposure therapy.

Limitations

The limitations of this study are consistent with limitations associated with using diagnosis codes as outcome measures. However, our study design ensured that codes were primary or secondary diagnoses in at least two separate VA health care visits at least 7 days apart (Hebert et al., 1999). Moreover, TBI severity and blast exposure based on the CTBIE are the most clinically focused data in the VA health system record, which allows for more accurate identification of TBI severity and blast exposure.

Conclusions and Future Directions

Optimizing the care of individuals with TBI is a critical mission of the Veterans Health Administration. Predictions based on outlined analyses will allow rehabilitation professionals to treat individuals with TBI more proactively by being able to identify individuals at risk for communication disorders based on injury severity, mechanism of injury, and demographic factors. Tracking and identifying these disorders could be implemented using an interdisciplinary model, whereby not only SLPs but all medical providers would be trained to identify these disorders. SLPs could then focus their efforts on providing in-depth cognitive and language assessment and creating individualized treatment plans, tailored to the veterans' functional goals.

Studies show that patients make a majority of their progress in recovery in the first year after their TBI-related injury, and marked improvements often plateau after this time frame (Christensen et al., 2008). The potential to predict communication disorders based on an individual's TBI severity could be significant for individualizing long-term rehabilitation plans and goals from the start of treatment, thereby saving treatment time and improving rehabilitation outcomes. It is imperative that SLPs and other rehabilitation personnel consider these factors at the onset of the rehabilitation process in order to optimize gains in therapy.

Current clinical practice guidelines for SLPs working in the Department of Defense and the VA system of care effectively delineate the role of the SLP working with these populations, accurately describe symptomatology related to TBI-related communication disorders, and recommend the use of interdisciplinary teams. However, it is difficult to assess how consistently these guidelines are implemented in routine clinical care. Veterans who are seen on an outpatient basis in a rural setting, for example, may not have as many opportunities to partake in cotreatment sessions as veterans in a VA polytrauma system of care hospital. The quality of speech-language pathology care in the VA system of care may likely be provider and location specific. Therefore, organizational changes might be more advantageous in making meaningful clinical changes. The results of this large-scale study can therefore be used to influence policy that can spur system-wide advances in speech-language pathology clinical care and research. Instituting training, appropriate staffing, and allocating resources to research in this area can facilitate these changes. For example, to date, there are no evidence-based assessments specific to mTBI-related communication disorders, despite the fact that mTBI is considered the signature injury of the war conflicts of Iraq and Afghanistan. Our study demonstrates just how significant this group of veterans is; the largest proportion of veterans diagnosed with a cognitive-communication disorders in our study had mTBI and would undoubtedly benefit from an accurate and sensitive diagnosis. Allocating VA funds to research a gold-standard assessment for this population would make an important and far-reaching clinical impact.

Future directions for research in this area include the tracking of symptoms and disorders longitudinally. The CENC (the parent study) Prospective Longitudinal Study is currently in Cycle 2: 2019–2023. The goal of the parent study is "to refine methods, enhance analyses, and apply results to identify predictors and longitudinal effects of mTBI." These effects of mTBI include the communication disorders identified in this study. In addition, using standardized measures common to both the Department of Defense and the VA, such as the Neurobehavioral Symptom Inventory, and developing trajectories of recovery based on symptomatology and performance and comparing results to the civilian sector can inform our understanding of the natural history of recovery for both blast- and no blast–related TBI. Integrating what is known about these injuries in the military setting versus the civilian setting is a worthwhile endeavor and can elucidate commonalities and differences among the two groups, which will aid rehabilitation professionals in treating communication disorders effectively and with compassion.

Author Contributions

Rocio S. Norman: Conceptualization (Equal), Investigation (Supporting), Methodology (supporting), Writing-original draft (Lead), Writing–Review and Editing (Lead), Funding acquisition (supporting), Project administration (Equal). **Alicia A. Swan:** Conceptualization (Supporting), Investigation (Supporting), Methodology (Supporting), Writing–Original Draft (Supporting), Writing–Review & Editing (Supporting). **Angela Jenkins:** Conceptualization (Supporting), Methodology (Supporting), Writing–Original Draft (Supporting), Writing–Review & Editing (Supporting). **Matthew Ballard:** Conceptualization (Supporting), Writing–Original Draft (Supporting), Writing–Review & Editing (Supporting). **Megan Amuan:** Data curation (Equal), Formal analysis (Lead), Methodology (Equal), Writing–Original Draft (Supporting), Writing–Review & Editing

(Supporting). **Mary Jo Pugh:** Conceptualization (Equal), Data curation (Equal), Formal analysis (Supporting), Funding acquisition (Lead) Investigation (Supporting), Methodology (Lead), Project administration (Equal), Resources (Lead), Supervision (Lead), Writing–Original Draft (Equal), Writing–Review & Editing (Equal).

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