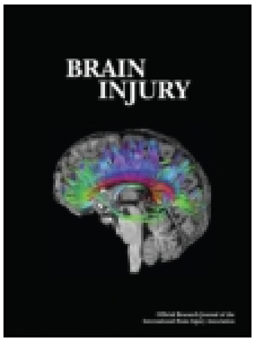

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ORIGINAL ARTICLE

Traumatic brain injury in veterans of the wars in Iraq and Afghanistan: Communication disorders stratified by severity of brain injury

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Abstract

Objective: To describe the prevalence of communication disorders in veterans of the wars in Iraq and Afghanistan with traumatic brain injury (TBI).

Design: Retrospective study of the prevalence of aphasia, fluency and voice disorders among veterans with different severity levels of TBI. Data was obtained from the VA National repository for OEF/OIF/OND veterans who received VA care in Fiscal Years 2010 and 2011.

Results: Among the 303 716 veterans in this study, 1848 were diagnosed with a communication disorder; 40% of these were also diagnosed with a TBI. Voice disorders were the most prevalent diagnosis (3.5 per 1000) followed by aphasia (1.9 per 1000) and fluency disorder (0.7 per 1000). Individuals with a TBI diagnosis were more likely to have a diagnosis of aphasia, followed by fluency and then voice disorder. The odds ratio (OR) of aphasia with TBI was 11.09–252.75 (95% CI = 8.78–441.52, $p < 0.01$). OR for fluency disorders with TBI was 3.58–10.41 (95% CI = 2.56–42.40, $p < 0.01$) and association of voice disorders with TBI was significant for all levels of TBI severity (OR = 1.5–6.61, 95% CI = 1.24–14.05, $p < 0.01$).

Conclusions: Veterans who sustained a TBI were more likely to have a diagnosis of a communication disorder, regardless of TBI severity. Those with TBI, including mild TBI, should be screened and evaluated for communication disorders.

Keywords

aphasia, epidemiology, fluency disorder, TBI severity, Veterans Health Administration, voice disorder

History

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Background

Human communication is an example of complex cognitive function where meaningful information is exchanged using speech, language and non-verbal gestures. These processes are thought to be the driving force behind the emergence of modern societal structures and advancement of ideas and cultural adaptations. Current understanding of brain functions related to human communication is founded on observations of individuals with acquired brain injuries and their resulting communication disorders. These studies began in the 1800s when Broca and Wernicke localized primary language areas for expressing and receiving language and later included Luria's [1] description of aphasia in soldiers during the Second World War [2]. The latter part of the 20th century was marked by the idea that speech-language impairments after traumatic brain injury (TBI) were distinct from deficits noted with focal neurological damage [3] and recent studies have identified changes in subcortical areas, such as the basal ganglia, as contributing factors to perceptual changes in speech patterns [4]. These findings are corroborated by advanced neuroimaging studies, which demonstrate diffuse axonal injury (DAI), as seen in mild TBI, in critical language areas [5–7]. The prevalence of communication disorders associated with varying severity of TBI has not been studied.

The US Center for Disease Control reports an average of 1.7 million people incur a brain injury per year and the majority of these injuries are mild TBI [8]. Warden [9] highlighted the high number of TBI as a result of the war conflicts in Iraq and Afghanistan. Fischer's [10] Report to Congress stated that, of the total 253 330 traumatic brain injury (TBI) cases (between 1 January 2000 and 20 August 2012), 194 561 have been mild (76.8%), 42 063 (16.6%) have been moderate, 6476 (2.5%) have been severe or penetrating and 10 210 have not been classifiable (4.0%) [11]. The Department of Veterans Affairs currently provides medical care for thousands of returning service members who have served in combat operations in Iraq and Afghanistan. Many of these veterans face challenges with community reintegration, often as a result of the chronicity of their medical conditions. Service members and veterans exposed to blast injuries are particularly at risk for developing communication disorders [12,13].

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Communication disorders affect an estimated 5–10% of the general population [14]. These estimates include voice and speech disorders (3%) and language disorders (<7%). Yairi and Ambrose [15] reported the prevalence rate for stuttering to be 1%, with an incidence of stuttering estimated at 4–5% [16]. Studies describing communication impairments after TBI have focused on the severe TBI population [17,18] with less of an emphasis placed on speech and language deficits associated with mild and moderate TBI. While Russell et al. [19] examined 'low-level' (i.e. word-level) language processing in the TBI population and Dion et al. [13] examined voice disorders in the absence of TBI comorbidity in US Army soldiers deployed to Iraq and Afghanistan, there are no studies that comprehensively describe prevalence rates for communication disorders spanning the areas of language, speech and voice by TBI severity levels.

This study identifies the prevalence of three distinct communication disorders: aphasia, fluency disorder and voice disorder in veterans of Operation Enduring Freedom/ Operation Iraqi Freedom/Operation New Dawn (OEF/OIF/ OND) who received healthcare in the Department of Veterans Affairs, Veterans Health Administration (VA) and among those with TBI, categorized by severity of injury (mild, moderate, severe and penetrating). These diagnoses were specifically chosen because of the effect they have over expressive communication skills and, consequently, the effect they may have over an individual's ability to reintegrate into the community and return to work successfully [14]. Furthermore, this study has analysed the incidence of communication disorders among diagnoses of various levels of TBI in order to test an association between communication disorders and TBI severity classifications.

Methods

Data sources and population

After obtaining IRB approval and receiving identifiers from the OEF/OIF/OND Roster File, data were gathered from the inpatient and outpatient files in the VA National Repository in Austin, TX, to conduct this retrospective study of the population of OEF/OIF Veterans who received VA care in both Fiscal Year 2010 (FY10: 1 October 2009–30 September 2010) and FY11 (1 October 2010–30 September 2011).

Measures

Dependent variables

The primary dependent variables included three distinct communication disorders: Aphasia, Voice Disorders and Fluency. This study used ICD-9-CM codes in inpatient (one diagnosis) and outpatient (two diagnoses at least 7 days apart) treatment files to define each condition. Aphasia was identified using codes 784.3 and 484.69. Fluency disorder was identified using codes 307.0 and 784.52. The code for developmental and CVA-related fluency disorders were excluded from the analysis, as it would have confounded the results for the fluency variable. Voice Disorder was defined using 784.40, 784.41, 784.49 and v41.4. A hierarchical variable was created with mutually exclusive categories, with the following priority: (1) aphasia, (2) apraxia of speech, (3) fluency disorder and (4) voice disorder.

Independent variables

The primary independent variable in this analysis was TBI. This study utilized those codes generated by the Department of Defense (DoD) to identify TBI as penetrating (injuries in which dura mater is breached), severe (normal or abnormal imaging; loss of consciousness [LOC] >24 hours; alteration of consciousness [AOC] >24 hours; post-traumatic amnesia [PTA] >7 days, moderate (normal or abnormal imaging; LOC >30 minutes and ≤24 hours; AOC >24 hours, PTA >1 day and <7 days), mild (normal imaging; LOC from 0–30 minutes; AOC is momentary up to 24 hours and PTA is from 0–1 day) and unclassifiable [20].

While the DoD and VA both use V-codes indicating 'history of TBI during military service' (V15.52X), in the VA setting these V-codes lack the fifth digit indicator which specifies TBI severity since data used to classify TBI severity is not available [21]. Therefore, individuals whose only TBI code in VA data was V15.52 comprise a separate category with no clear severity level and were excluded from the final analysis.

Descriptive characteristics

Descriptive characteristics of this cohort of veterans were obtained from the OEF/OIF/OND Roster File and the inpatient and outpatient Medical SAS data sets. Demographic characteristics included age, race/ethnicity (White, Black, Hispanic, Other, Unknown) and education level (less than high school education, high school diploma, some college, college graduate, graduate/professional school). The initial analysis included variables such as branch of service, military rank and component (Active Duty vs non-Active Duty); however, these variables were excluded from the final analysis due to the need to limit the number of variables for multivariable analyses and collinearity with other variables such as economic and educational status. The diagnoses analysed are not inclusive of all communication disorders that may result from TBI; cognitive-communication disorders, language disorders at the discourse level and disorders of pragmatic skills (e.g. turn-taking and eye-gaze) were excluded from this analysis due to the complex nature of diagnosing these conditions using ICD-9 codes., which were the primary measures used in this study. Apraxia of speech and dysarthria were initially included, but excluded from the final analysis due to their low prevalence in the cohort.

Analysis

The prevalence of each communication disorder included in this study is provided first, followed by the descriptive statistics (analysis of variance or chi-square as appropriate) for individuals in each category of communication disorder, including TBI severity. Finally, results are shown of logistic regression analyses predicting each type of communication disorder compared to those without any diagnosed communication disorder. All analyses were conducted using SAS software® version 9.2 (Cary, NC) and $p < 0.05$ was used as the level of statistical significance.

Table I. Characteristics of OEF/OIF/OND veterans by aphasia, fluency disorder and voice disorder (cohort: total $n = 303\,716$)*.

Characteristic	No speech/language disorder $n = 301\,868$ (99.4%)	Aphasia $n = 567$ (0.2%)	Fluency disorder $n = 205$ (0.1%)	Voice disorder $n = 1055$ (0.4%)	p
Mean age	35.9 (SD 9.86)	36.35 (SD 9.93)	36.09 (SD 9.14)	40.55 (SD 10.83)	<0.0001
Sex, female (%)	40 327 (13.4)	38 (6.7)	11 (5.4)	179 (17.0)	<0.0001
Married, yes (%)	136 695 (45.3)	273 (48.2)	89 (43.4)	533 (50.5)	0.0048
Non-exempt co-pay (%)	64 429 (21.3)	23 (4.1)	24 (11.7)	144 (13.7)	<0.0001
Race/ethnicity (%)					<0.0001
White	190 776 (63.2)	389 (68.6)	135 (65.9)	578 (54.8)	
African-American	52 087 (17.3)	64 (11.3)	42 (20.5)	267 (25.3)	
Hispanic	35 564 (11.8)	72 (12.7)	22 (10.7)	140 (13.3)	
Other	12 151 (4.0)	32 (5.6)	5 (2.4)	45 (4.3)	
Unknown	11 290 (3.7)	10 (1.8)	1 (0.5)	25 (0.2)	
Education (%)					<0.0001
Less than High School	3891 (1.3)	6 (1.1)	3 (1.5)	15 (1.4)	
High School or equiv.	232 877 (77.2)	467 (82.4)	164 (80.0)	748 (70.9)	
Some College	30 497 (10.1)	46 (8.1)	16 (7.8)	137 (13.0)	
College Grad	23 111 (7.7)	33 (5.8)	15 (7.3)	91 (8.6)	
Post-College	7633 (2.5)	8 (1.4)	5 (2.4)	51 (4.8)	
Unknown	3859 (1.3)	7 (1.2)	2 (1.0)	13 (1.2)	

*Twenty-one members of the cohort had a diagnosis of apraxia/dysarthria but are not described in this table.

Results

Prevalence of communication disorders

Table I shows that, within this cohort of 303 716 Veterans, 0.6% ($n = 1848$) were diagnosed with one or more of the following communication disorders; Aphasia, Fluency Disorder, Voice Disorder and/or Apraxia/Dysarthria. Among the 1848 speech-language disorders diagnosed, 21 cases of apraxia of speech or dysarthria were identified, which were too few to examine in greater detail. Table I shows prevalence rates and descriptive statistics for individuals diagnosed with each type of communication disorder. Voice Disorder was the most prevalent diagnosis in the OEF/OIF/OND cohort and comprised 57.1% ($n = 1055$, 3.5 per thousand overall) of all communication disorders diagnosed. The second most prevalent type of communication disorder was Aphasia, which accounted for 31% ($n = 567$, 1.9 per thousand) of all communication disorders. Fluency disorders were less prevalent in this cohort and comprised the remaining 11.1% ($n = 205$, 0.7 per thousand) of communication disorders.

Because of the large sample, comparisons for all descriptive variables were statistically significant. The most clinically/theoretically important differences are included in Table I, which shows age varying significantly across the groups. Individuals with voice disorder were significantly older than other groups, including those with aphasia ($F = 59.16$; df = 4, $p < 0.0001$). There were also significant differences between groups on the remaining demographic characteristics. Individuals diagnosed with aphasia and fluency were less likely to be women and those with voice disorder were more likely to be women than expected by chance ($\chi^2 = 46.23$; df = 4; $p < 0.0001$). Individuals with voice disorder and aphasia were more likely to be married, while those with fluency disorder were less likely to be married than expected by chance ($\chi^2 = 14.8$; df = 4; $p = 0.005$). Individuals with aphasia and fluency disorder were more likely to be white non-Hispanic than expected, while those with voice disorder and fluency disorder were more likely to be African American than expected and those with voice disorder were less likely to be Hispanic than expected by chance ($\chi^2 = 97.00$; df = 16; $p < 0.0001$). With regard to education level, individuals with aphasia were more likely to have high school or equivalent education and less likely to have completed college, while those with voice disorder were more likely to have college or post-graduate education than expected by chance ($\chi^2 = 54.09$; df = 20; $p < 0.0001$).

TBI prevalence and communication disorder by TBI severity

Of the 303 716 veterans included in this study, 14% ($n = 42\,593$) were diagnosed with a TBI; among those with a communication disorder, 40% had a TBI diagnosis. The proportion with a TBI diagnosis varied significantly by communication disorder type: aphasia 77.1%, fluency disorder 42% and voice disorder 19.8%. Among TBI diagnoses, the majority were of mild severity level 65.6% ($n = 961$), followed by moderate 33.1% ($n = 14\,117$), severe 0.9% ($n = 382$) and penetrating 0.3% ($n = 123$).

Figure 1 illustrates the relationship between the selected communication disorders and TBI severity levels. Figure 1(a) demonstrates that the majority of individuals (86.1%, $n = 260\,017$) without a communication disorder also did not have a history of TBI. However, the remaining number of individuals did, with the greatest amount (9.2%, $n = 27\,615$) in the mild TBI category. Figure 1(b) shows a different trend, in that the greater concentration of those identified as having aphasia fell into the moderate TBI category (40.9%, $n = 232$), followed by mild TBI (29.6%, $n = 168$) and no history of TBI (22.9%, $n = 130$). Figure 1(c) shows the highest number of individuals with fluency disorder pertaining to the 'no history of TBI' category (58.1%, $n = 119$), followed by mild TBI (25.4%, $n = 52$) and moderate (15.6, $n = 52$). Lastly, Figure 1(d) shows a positive relationship between voice disorders and 'no history of TBI' (80.2%, $n = 846$), mild TBI (11.9%, $n = 126$) and moderate TBI (7.2%, $n = 76$).

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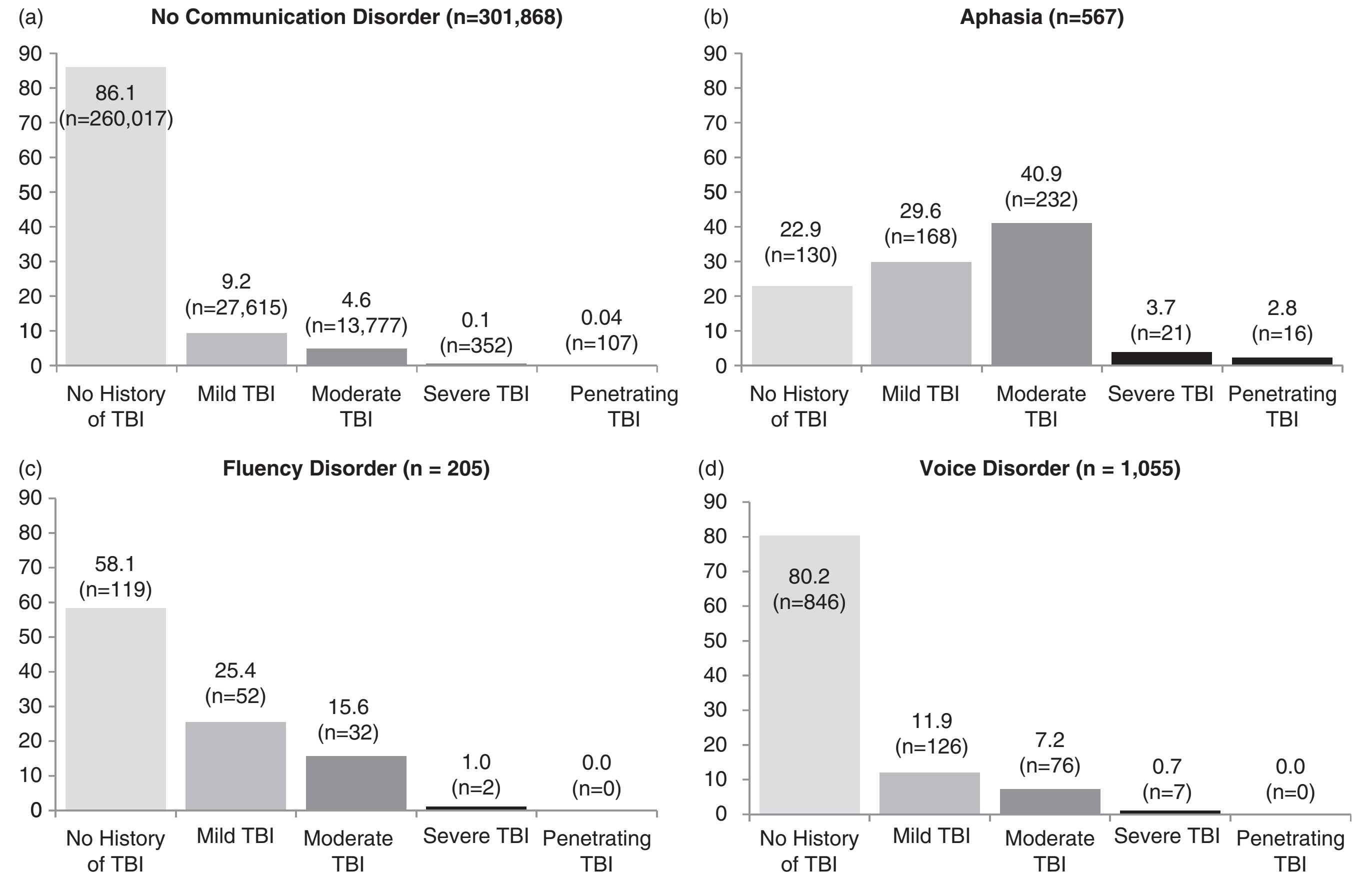

Figure 1. Prevalence of no communication disorder, aphasia, fluency disorder and voice disorder in OEF/OIF/OND veterans by TBI severity level. (a) Prevalence of no communication disorder among OEF/OIF/OND veterans by TBI severity; (b) Prevalence of aphasia among OEF/OIF/OND veterans by TBI severity; (c) Prevalence of fluency disorder among OEF/OIF/OND veterans by TBI severity; and (d) Prevalence of voice disorder among OEF/OIF/OND veterans by TBI severity.

Logistic regression analysis for TBI and communication disorders

Table II shows adjusted odds ratios from logistic regression analyses predicting each communication disorder. After controlling for demographic characteristics, the odds of aphasia were significantly higher for those with any level of diagnosed TBI [adjusted odds ratio (AOR) = 11.09–252.75, 95% confidence interval (CI) = 8.78–441.52]. Examination of the confidence intervals for each TBI severity level indicates that there was no overlap of confidence intervals for any of the TBI severity levels. Thus, the odds of aphasia were significantly higher for penetrating TBI than for severe, moderate or mild TBI, the odds for severe TBI were significantly higher than for moderate or mild TBI and the odds for moderate TBI were significantly higher than for mild TBI.

For fluency disorder, the odds were increased for all TBI severity groups with the exception of penetrating TBI, for which there were no cases [adjusted odds ratio (AOR) = 3.58–10.41, 95% confidence interval (CI) = 2.56–42.40]. Examination of confidence intervals showed overlap for all levels of TBI, indicating that, while elevated, the odds of fluency disorder among those with severe, moderate and mild TBI were not significantly different from each other.

Compared to no TBI, the odds for voice disorder were higher for all levels of TBI except penetrating, for which there were no cases [adjusted odds ratio (AOR) = 1.5–6.61, 95% confidence interval (CI) = 1.24–14.05]. Examination of confidence intervals showed no overlap for severe TBI, but overlap of confidence intervals for mild and moderate TBI. This indicates that the odds of voice disorder for those with severe TBI were significantly higher than the odds for voice disorder with moderate and mild TBI. There was not a statistically significant difference between the odds for moderate and mild TBI (Table II).

Discussion

During the study period (FY 2010–2011), 1848 veterans (0.6%) of OEF/OIF/OND veterans were diagnosed with a communication disorder and 40% of those had a concomitant TBI diagnosis. The majority (77%) of the individuals diagnosed with aphasia were also diagnosed with a TBI of varying severity and the association of particularly the severe and penetrating TBI validates the data for the remaining communication disorders; this finding is consistent with prior literature citing language deficits with TBI [22].

Within the overall OEF/OIF/OND cohort (inclusive of those with and without TBI), voice disorder was the most prevalent communication disorder and comprised 58% of all communication disorders diagnosed, followed by Aphasia (31% of cases), fluency disorder (11% of cases) and

Table II. Logistic regression predicting communication disorders in OEF/OIF veterans (total observations read: $n = 303\,716$).

Characteristic	Aphasia ($n = 567$)		Fluency disorder ($n = 205$)		Voice disorder ($n = 1055$)	
	Adjusted odds ratio	95% Wald confidence limit	Adjusted odds ratio	95% Wald confidence limit	Adjusted odds ratio	95% Wald confidence limit
Sex (female vs male)	0.89	0.64–1.25	0.42	0.23–0.78	1.34	1.13–1.58
Married (no vs yes)	0.85	0.71–1.01	1.03	0.78–1.37	0.95	0.84–1.08
Age (vs 17–49)						
50–65	1.68	1.28–2.21	0.66	0.38–1.15	2.23	1.90–2.61
65+	2.35	0.32–17.14	*	*	3.27	1.34–7.98
Ethnicity (vs White)						
African American	0.78	0.60–1.02	1.38	0.97–1.97	1.57	1.35–1.82
Hispanic	0.95	0.74–1.23	0.87	0.56–1.37	1.25	1.04–1.51
Other	1.4	0.97–2.01	0.61	0.25–1.49	1.16	0.86–1.58
Unknown	0.67	0.35–1.26	0.18	0.02–1.25	0.82	0.55–1.23
Poverty status (vs exempt from co-pay)						
Non-exempt	0.29	0.19–0.44	0.57	0.37–0.87	0.57	0.47–0.68
Unclassified	0.85	0.53–1.36	0.1	0.01–0.73	0.15	0.08–0.29
Education (vs HS grad/equiv)						
Less than HS	0.81	0.36–1.82	1.12	0.36–3.49	1.23	0.74–2.06
Some college	0.94	0.69–1.28	0.96	0.57–1.61	1.26	1.04–1.52
College graduate	0.97	0.68–1.40	1.28	0.75–2.19	1.1	0.88–1.38
Post-college degree	0.72	0.35–1.48	1.6	0.64–4.00	1.6	1.19–2.16
Unknown	0.88	0.41–1.87	0.7	0.19–3.11	0.97	0.56–1.68
TBI (vs no TBI)						
Penetrating TBI	252.75	144.69–441.52	*	*	*	*
Severe TBI	108.63	67.42–175.03	10.41	2.56–42.40	6.61	3.11–14.05
Moderate TBI	29.65	23.77–36.98	4.31	2.90–6.40	1.74	1.37–2.21
Mild TBI	11.09	8.78–14.02	3.58	2.57–4.99	1.5	1.24–1.82

*Too few cases to include in analysis.

dysarthria/apraxia of speech accounted for less than 1% of all communication disorders diagnosed in this cohort.

The conflicts in Iraq and Afghanistan have caused more head, neck and face wounds than previous [23]. Head injuries, a result of primary blast exposure and secondary and tertiary mechanisms, make up the majority of injuries and remain, unfortunately, misunderstood in the literature [9,24]. In this study, head injuries might potentially account for ~23% of communications disorders. This finding should be examined in the post-deployment context; while the VA TBI Screening Tool (VABIST) has been implemented in the VA since 2007 to capture symptoms associated with TBI, communication disorders may be overlooked and, in the absence of a clinical diagnostic session, it may be that the TBI diagnosis itself is under-diagnosed [25].

The high number of voice disorders in the general OEF/OIF/OND population may be multi-factorial. Injuries to the head and neck would put individuals at significant risk for organic voice disorders [26] such as laryngeal trauma from either external forces [27] or laryngeal hypofunction due to reduced cranial nerve innervation or 'low vocal effort' due to impaired cognitive status after TBI [28].

In addition to the high number of injury-related pathologies, the incidence of substance abuse, gastro-esophageal reflux disease, vocal demands and comorbid mental health conditions in this population warrants closer examination as contributing aetiologies [13,29]. Roy and Bless [30] also found that voice disorders such as spasmodic dysphonia and muscle tension dysphonia are often related to mental health diagnoses, as the laryngeal vestibule is highly vulnerable to emotional changes, which have been previously linked to increased tension and hypertonicity of the laryngeal muscles, which often underlie voice disorders. These emotional changes may be associated with emotional trauma, anxiety, depression and related somatic complaints. PTSD, an anxiety disorder prevalent in this population of veterans [31], may also be considered a possible risk factor for voice disorders in these service members deployed to combat zones [13] and, furthermore, the symptoms of PTSD and TBI overlap [32].

In our analysis, aphasia was the most prominent diagnosis among those with TBI of any severity level and this was clearly linked with aphasia, followed by voice disorders and fluency disorders. In this analysis, aphasia was the most prevalent diagnosis among the veterans with severe TBI. The link between severe TBI and language deficits has been well-established in the literature. The findings for communication disorders among those with mild-to-moderate TBI, however, were unexpected. Brain injuries in these categories (and especially mild TBI) are associated with pathologies involving diffuse damage of cortical areas vs direct structural damage of the language centres. However, recent research has shown that DAI may 'predominantly affect the frontal and parietal lobes', the regions of brain that are critical to language processing [6]. Saunders and Echt [33] cited that individuals exposed to blast mechanisms may also incur injuries in associated sensory organs such as the auditory and visual systems, which would impact communication.

This study expands the literature by illustrating a significant association between aphasia and mild-to-moderate TBI. This has not been described in prior studies of military or civilian population with head injuries and no prior studies have used the severity stratification approaches taken here. A source of these negative changes in language function may be that the cognitive domains that support language and speech, including attention and information processing, may be depressed in the mild-to-moderate cohort, as previously reported in the civilian literature [34,35]. Indeed, Vasterling et al. [36] provided data that suggest compromised attention, memory and new learning after deployment, all of which are vital to intact language functioning. These changes to cognitive domains would contribute to language difficulties and result in decreased comprehension, word-finding difficulties and non-fluent speech.

In this study, fluency disorder was the least diagnosed communication disorder in the general OEF/OIF/OND population and also within the TBI analysis; this is consistent with the low incidence rate of this disorder in the general population. The number of diagnosed cases of fluency disorders within the TBI population was higher among individuals with mild or moderate TBI than among those with severe or penetrating TBI. This finding may be surprising, given that, historically, research in this area would lead one to expect a higher incidence of fluency disorders among those with penetrating TBI [37] and other severe neuropathologies affecting cortical areas [38]. More recent studies in the area of acquired fluency disorders have examined the possibility of subcortical areas such as the basal ganglia being affected in individuals who stutter [4] and that acquired fluency disorders 'rarely involves speech and language systems in the left hemisphere' [39]. To what extent subcortical areas are affected after blast-induced TBI remains to be explored. The role of PTSD and fluency is another area of interest, given the strong association between anxiety disorders and stuttering in the literature [40,41]. The low prevalence rate of fluency disorder in this study may also be attributable to the complex nature of diagnosing fluency disorders, due to the variability in its presentation. Given the hierarchical methodology in this study, it is possible that some of the stutterers in this analysis may have been classified within the aphasia diagnosis, i.e. halting, non-fluent speech may present to some providers as aphasia rather than stuttering and vice-versa.

Limitations of the study

Limitations of this study include and are not limited to the process in which these diagnoses were made. Although these analyses ensured that the communication disorders were diagnosed at two separate visits within the VA system, there is limited information that one can glean about the diagnostic process, including who entered the diagnosis and their experience with diagnosing communication disorders and whether any diagnostic testing was completed to arrive at the diagnosis or if the diagnosis was the result of patient self-report. In addition, the diagnostic categories are broad. For example, the category of aphasia may include patients with severe Broca's aphasia as well as milder forms of aphasia such as anomia. Despite these possible variations in severity, the categories indicate a similar injury process underlying the expressed pathology that is informative about the mechanisms of injury in the different TBI severities.

Additionally, unlike Mohr et al. [42], there is little information about the mechanism of injury or site of lesion for those patients who incurred TBI. One can assume that a significant portion of these patients suffered TBI secondary to blast exposure and this has been documented for mTBI in particular. Cherney et al.'s [12] speech-language pathology position paper emphasized the 'structural, peripheral and central nervous system damage' as a result of blast injuries and the likely connection between these injuries and speech-language disorders. This report implicates physical deficits which can affect 'accuracy, timing and co-ordination of speech' as well as verbal expression, thought organization, verbal fluency and word-finding.

Finally, prior studies have not used this method of classifying disease severity; however, the findings support the face validity of the coding algorithm used by the Department of Defense over the past decade.

Conclusions

The clinical implications of the findings emphasize a general need to monitor and evaluate those with all severity levels of TBI for communication disorders. Historically, studies in the area of communication disorders and acquired brain damage have addressed clinical symptoms related to severe neurological injury, perhaps as a result of the more immediate acute medical needs of these patients and the potential for life-long physical and mental health impairment [43]. The results of this study demonstrate that mild and moderate TBIs are also associated with communication disorders, which could interfere with long-term community reintegration goals. The analysis shows a previously undescribed association between mild TBI and the three communication disorders investigated. This trend calls for an expansion of the clinical focus to include those who have suffered mild-to-moderate TBI.

The communication deficits of individuals with mild TBI pose a clinical challenge to the clinician, as deficits in this population are often subtle and subjective in nature [44,45] and the diagnosis of a speech or language disorder is in itself, 'an inexact and subjective science' [46]. Co-morbid mental health conditions, including depression, anxiety disorder, PTSD and substance abuse, which are noted to be prevalent in this cohort of combat veterans [31,47], may also contribute to the number of communication disorders, as these conditions can independently affect executive function and processing speed [48], which are critical to effective communication [49]. Whether this can be attributed to neurological vs psychological functioning remains an area to be explored. The association between communication disorders and mental health conditions is likely complex and multifactorial, as there is evidence that TBI and behavioural health complaints overlap, with possible diagnostic and therapeutic implications, including chronicity of symptoms [47,50]. The relationship between mental health disorders, communication disorders and TBI is beyond the scope of this paper, but warrants further examination. Future directions for research should include identifying the mechanisms underlying communication disorders in mild and moderate TBI, the accurate diagnosing of communication disorders after blast-related TBI and the relationship between mental health disorders such as PTSD and communication disorders. The answers to these questions will come from the appropriate tracking of individuals affected by these disorders and contribute to the much-needed long-term outcome studies in TBI.

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Declaration of interest

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