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An Examination of Racial/Ethnic Differences on the Neurobehavioral Symptom Inventory Among Veterans Completing the Comprehensive Traumatic Brain Injury Evaluation: A Veterans Affairs Million Veteran Program Study

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Abstract

Objective: The purpose of this study was to explore racial/ethnic differences in neurobehavioral symptom reporting and symptom validity testing among military veterans with a history of traumatic brain injury (TBI).
Method: Participants of this observational cross-sectional study ($N = 9{,}646$) were post-deployed Iraq-/Afghanistan-era veterans enrolled in the VA's Million Veteran Program with a clinician-confirmed history of TBI on the Comprehensive TBI Evaluation (CTBIE). Racial/ethnic groups included White, Black, Hispanic, Asian, Multiracial, Another Race, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander. Dependent variables included neurobehavioral symptom domains and symptom validity assessed via the Neurobehavioral Symptom Inventory (NSI) and Validity-10, respectively.
Results: Chi-square analyses showed significant racial/ethnic group differences for vestibular, somatic/sensory, and affective symptoms as well as for all Validity-10 cutoff scores examined ($\geq$33, $\geq$27, $\geq$26, $>$22, $\geq$22, $\geq$13, and $\geq$7). Follow-up analyses compared all racial/ethnic groups to one another, adjusting for sociodemographic- and injury-related characteristics. These analyses revealed that the affective symptom domain and the Validity-10 cutoff of $\geq$13 revealed the greatest number of racial/ethnic differences.
Conclusions: Results showed significant racial/ethnic group differences on neurobehavioral symptom domains and symptom validity testing among veterans who completed the CTBIE. An enhanced understanding of how symptoms vary by race/ethnicity is vital so that clinical care can be appropriately tailored to the unique needs of all veterans. Results highlight the importance of establishing measurement invariance of the NSI across race/ethnicity and underscore the need for ongoing research to determine the most appropriate Validity-10 cutoff score(s) to use across racially/ethnically diverse veterans.

Keywords: Head injury; Traumatic brain injury; Assessment; Symptom validity testing

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Introduction

With an estimated one in five Iraq- and Afghanistan-era veterans having a history of traumatic brain injury (TBI; MacGregor et al., 2010; Swanson et al., 2017; Terrio et al., 2009), the Veterans Health Administration (VHA) has long prioritized evaluation and treatment of TBI and underscored the importance of improving the understanding of TBI outcomes and recovery (The Management and Rehabilitation of Post-Acute Mild Traumatic Brain Injury Work Group, 2021). Although many existing studies have examined TBI sequelae, clinical outcomes, and recovery trajectories among veterans, much of this research has occurred within racially homogenous samples of predominantly non-Hispanic White adults. To better inform evidence-based clinical practice and ensure that equitable, tailored, and culturally competent care is being offered to all veterans with TBI histories, there is an urgent need for more inclusive research studies and practices centered on examining racially/ethnically diverse samples of veterans that better reflect the demographic makeup of the U.S. military.

To date, a sizeable body of literature on civilian populations has shown that TBI-related clinical outcomes vary based on race and ethnicity (for a review, see Arango-Lasprilla & Kreutzer, 2010; Brenner et al., 2020); however, analogous studies on service member and/or veteran populations are comparatively limited. Of the existing studies examining the associations between race/ethnicity and TBI history among veteran populations, the majority have evaluated TBI diagnostics (Dismuke, Gebregziabher, Yeager, & Egede, 2015; Evans et al., 2013; Kysar-Moon & Mustillo, 2019), mortality risk (Dismuke, Gebregziabher, & Egede, 2016; Egede, Dismuke, & Echols, 2012), or psychosocial outcomes (Clark, Seewald, Wu, Jak, & Twamley, 2020; Dismuke et al., 2016; Egede et al., 2012). This research has generally found that racially/ethnically diverse veterans tend to experience worse outcomes in these domains compared to their non-Hispanic White counterparts. For example, Kysar-Moon and Mustillo (2019) reported that racially/ethnically diverse service members were less likely to receive a TBI diagnosis than non-Hispanic White veterans and Egede and colleagues (2012) found that, among veterans with a TBI diagnosis, Hispanic/Latino/a/x (henceforth Hispanic) veterans had higher mortality rates than non-Hispanic veterans. Additionally, race and ethnicity have been significantly associated with VA service utilization (Dismuke et al., 2016), ability to return to productive work (Mortera, Kinirons, Simantov, & Klingbeil, 2018), and work status (Vanderploeg, Curtiss, Duchnick, & Luis, 2003), with generally poorer outcomes for racially/ethnically diverse veterans. These disparities can likely be explained by systemic and structural inequities, such as access to health care and transportation and the quality of available health-care services, but are also the direct consequence of structural racism and discrimination (e.g., provider bias), which is largely directed toward and especially harmful for individuals from marginalized groups (Saha et al., 2008; Shim, 2021; Shim et al., 2014).

Racial/ethnic differences have also been observed in neurobehavioral symptom reporting as well as in psychiatric and neurological/physical sequelae in civilian populations following TBI (Arango-Lasprilla et al., 2012; Hart et al., 2014; Perrin et al., 2014; Swan et al., 2018); however, very few military studies have examined racial/ethnic differences in these domains. Of the existing military TBI studies, results have been mixed, with some studies finding racial/ethnic differences (Schwab et al., 2017) and others finding no differences (Lange et al., 2013; Soble et al., 2014), particularly with respect to neurobehavioral symptom reporting. Thus, more research is needed to better understand the extent to which symptom reporting patterns vary across the different racial/ethnic groups among military veterans and to ensure the lived experiences of marginalized community members are adequately described, understood, and taken into consideration during clinical intervention initiatives. Moreover, an untapped but equally important area of exploration is the evaluation of racial/ethnic differences on measures of symptom validity. Within the VHA, the Neurobehavioral Symptom Inventory (NSI; Cicerone & Kalmar, 1995) is commonly used to assess neurobehavioral symptoms, and several studies have evaluated its embedded symptom validity test (SVT), the Validity-10 (Armistead-Jehle et al., 2018; Bodapati et al., 2019; Dretsch et al., 2017; Lange, Brickell, & French, 2015; Vanderploeg et al., 2014). However, no studies, to our knowledge, have explicitly evaluated racial/ethnic differences across the various Validity-10 cutoff scores that have been established, leaving a large knowledge gap in the SVT literature. This is especially important because the convenience samples utilized in the development of these indices were largely racially/ethnically homogeneous, which threatens validity.

When considering the existing civilian and military research examining racial/ethnic disparities in clinical outcomes following TBI, several limitations must be acknowledged. A primary limitation has been researchers' inadequate engagement with racially/ethnically diverse groups and the under-recruitment of racially/ethnically diverse groups in TBI research, which is often demonstrated through either small sample sizes or the exclusion of some racial/ethnic groups entirely. Another limitation is the practice of collapsing many racial/ethnic groups into an "Other" category when making racial/ethnic comparisons (e.g., White, Black, Hispanic, and Other), which is problematic given the unique experiences and barriers certain groups may face. Certainly, these limitations influence one another, as the exclusion of certain groups from critical research initiatives has led to examining broad, non-specific groups (or "lumping"; Schwabisch & Feng, 2021), with the justification that these practices were "to allow for adequately powered studies" instead of investigating the unique outcomes and risk factors for each group. Thus, there is a tremendous need for TBI research—especially within military samples—to increase the representation of racially/ethnically

diverse participants. It is also imperative that studies evaluate race/ethnicity as a primary variable of interest rather than as a covariate to further establish and inform the relationship between race/ethnicity and TBI outcomes in veteran samples. Finally, it is important to acknowledge that although race/ethnicity is the construct being examined, there are many underlying variables contributing to this construct, including contextual and social determinants of health (e.g., housing instability, adverse early life experiences, food insecurity) that are the direct consequences of inequitable systems of power and oppression that reinforce systemic racism and discrimination (American Medical Association, 2021-2023; Shim, 2021; Shim et al., 2014).

Although sustaining a head injury presents challenges for all veterans, existing evidence suggests that racially/ethnically diverse veterans experience poorer outcomes relative to non-Hispanic White veterans (Dismuke et al., 2016; Egede et al., 2012; Kysar-Moon & Mustillo, 2019; Mortera et al., 2018; Schwab et al., 2017; Vanderploeg et al., 2003). Better understanding these disparities is critical to improving clinical care. Furthermore, the current clinical practice guidelines that are used within the VHA have been largely based on studies that draw from predominantly non-Hispanic White samples, which raises questions of generalizability and relevance for racially/ethnically diverse veterans with a history of TBI. To address these challenges, we examined data from the Million Veteran Program (MVP), a VA-wide research initiative that examines the relationships between military experiences, lifestyle factors, genes, and health among veterans (Gaziano et al., 2016). Due to the large-scale nature of the MVP project and its purposeful recruitment of veterans from a wide range of racial/ethnic groups that have been previously understudied, MVP offers a unique opportunity to examine the health disparities among veterans with a history of TBI. In the present study, we examined data from MVP-enrolled veterans who completed a Comprehensive Traumatic Brain Injury Evaluation (CTBIE; Department of Veterans Affairs, 2007, 2010; Scholten, Sayer, Vanderploeg, Bidelspach, & Cifu, 2012) and had a CTBIE-confirmed history of TBI. The overall purpose of this study was to explore racial/ethnic differences in NSI symptom domains and symptom validity among veterans with a history of TBI. This was designed as an exploratory study; thus, no a priori hypotheses were proposed.

Materials and Methods

Procedures and Participants

The present observational cross-sectional study included post-deployed Iraq-/Afghanistan-era veterans enrolled in the MVP (see Gaziano et al., 2016 for a complete description of MVP procedures) with a history of TBI. The MVP was approved through the VA's Central Institutional Review Board in 2010, and participant enrollment began in 2011. All veterans are eligible to enroll in MVP independently of receiving care at the VA. Upon consenting to participate in MVP, veterans complete two comprehensive questionnaires related to demographics and psychosocial variables, military service, medical history, and health behaviors; provide a blood sample for genetic analysis; and allow investigators access to their (de-identified) electronic health record (EHR). For the current study (conducted under "MVP026"), only EHR-based data gathered from the VA's Corporate Data Warehouse (CDW; Fihn et al., 2014) were examined. The data collection period was October 2007–October 2019. Inclusion criteria included a CTBIE-confirmed history of TBI (described later) and complete data on self-reported race and ethnicity. Of the 17,177 MVP-enrolled veterans who completed the CTBIE, 6,371 were excluded due to negative, missing, or uncertain TBI diagnostic data on the CTBIE and 1,160 participants were excluded due to unknown or missing race and ethnicity data, resulting in a study sample of $N = 9{,}646$. Supplementary material online, Table S1 includes participant characteristics for the overall sample.

Data Sources and Key Variables

Race/ethnicity. Race/ethnicity data were gathered from the CDW. Veterans self-reported their racial identity, selecting from the following options: White; Black or African American; Asian; American Indian or Alaska Native; Native Hawaiian or Other Pacific Islander; Multiracial; Other; or Unknown. Veterans also self-reported their ethnicity, selecting from the following options: Hispanic or Latino, Not Hispanic or Latino, or Unknown. If veterans reported Hispanic or Latino ethnicity, they were assigned to the "Hispanic" group. Veterans who did not report Hispanic or Latino ethnicity were then assigned to a group based on the race they reported. The following exclusive racial/ethnic groups were derived from these variables to create a combined race/ethnicity variable: "Hispanic" (of any race), "White," "Black," "Asian," "American Indian or Alaska Native," "Native Hawaiian or Other Pacific Islander," "Multiracial," and Other ("Another Race"). As mentioned previously, any veteran endorsing "Unknown" for their race or ethnicity was excluded, as was anyone with missing race or ethnicity data. For the purpose of this study, we adhered to the pre-determined racial/ethnic categories that were used during data collection, but where possible, amended labels to be consistent with the current guidelines provided by the American Psychological Association's guidelines for bias-free language

and the Urban Institute's Do No Harm Guide (American Psychological Association, 2019; Schwabisch & Feng, 2021). We also acknowledge that the racial/ethnic categories we utilized do not allow for examining intersectionality.

Comprehensive Traumatic Brain Injury Evaluation

All veterans included in the present study completed the CTBIE. The CTBIE was implemented in the VHA in 2007 (Department of Veterans Affairs, 2010) for the purpose of diagnosing historical TBIs in Iraq- and Afghanistan-era veterans with a positive TBI screen (see VHA Directive 2007-013 [VHA, 2007] and VHA Directive 2010-012 [VHA, 2010] for an overview of the TBI screen). The psychometrics of the CTBIE and TBI screen have been described previously, with both measures generally showing better sensitivity than specificity (Belanger, Vanderploeg, Soble, Richardson, & Groer, 2012; Fortier, Amick, Kenna, Milberg, & McGlinchey, 2015; Pape et al., 2018; Radigan, Mcglinchey, Milberg, & Fortier, 2018). Despite the psychometric variability, the CTBIE and TBI screen are widely utilized across the VHA and thus there is an inherent value in evaluating outcome data associated with these measures.

As part of the CTBIE structured interview, veterans are asked about basic demographic and psychosocial information as well as injuries sustained during deployment that could have resulted in a TBI. For each possible TBI event, veterans are questioned about injury characteristics such as loss of consciousness (LOC), alteration of consciousness (AOC), and post-traumatic amnesia (PTA) as well as mechanism of injury (i.e., bullet, vehicular, fall, and blast). Additionally, the CTBIE gathers information about TBIs sustained both before and after deployment (i.e., "Prior to your OEF/OIF deployment, did you experience a brain injury or concussion?" and "Since your OEF/OIF deployment, have you experienced a brain injury or concussion?"). After the CTBIE interview has been completed, clinicians are asked to determine the veteran's TBI diagnostic status by answering "yes" or "no" to the following questions: "Based on the history of the injury and the course of clinical symptoms, did the Veteran sustain a TBI during OEF/OIF deployment?" Clinicians are instructed to make their diagnostic decision based on the presence/absence of LOC, AOC, and PTA. Only veterans with a CTBIE-confirmed history of TBI (i.e., a "yes" to this diagnostic question) were included in this study.

Neurobehavioral Symptom Inventory

The 22-item NSI, a self-report measure, was administered as part of the CTBIE (Cicerone & Kalmar, 1995; Department of Veterans Affairs, 2010) to measure participants' endorsement of neurobehavioral (or "post-concussive") symptoms. Participants are asked to evaluate the extent to which each symptom (e.g., feeling dizzy, headaches, and poor concentration) has affected them over the past 30 days using a scale of 0–4, where "0" indicates "none" and "4" signifies "very severe." For this study, symptom domain scores were calculated for the NSI based on previous factor analyses by Meterko and colleagues (2012) and Vanderploeg and colleagues (2015) who utilized a similar sample (i.e., service members with a history of TBI): vestibular (sum of items 1–3, range 0–12), somatic/sensory (sum of items 4–7 and 9–11; range 0–28); cognitive (sum of items 13–16; range 0–16), and affective (sum of items 17–22; range 0–24). Supplementary material online, Table S2 includes descriptive statistics for these variables. After generating a total score for each symptom domain, scaled scores were computed by dividing each symptom domain total score by the number of items comprising each domain, resulting in scores ranging from 0 to 4. From there, scores were dichotomized into "not severe" (scaled score < 3) and "severe" (scaled score ≥ 3) groups, with the latter reflecting clinically significant symptoms, which is consistent with prior research (Bouldin et al., 2021; Iverson et al., 2011).

In addition to examining NSI symptom domain scores, there is another question included within the CTBIE that assesses symptom interference, or the extent to which participants' lives have been affected by the NSI symptoms during the past 30 days (i.e., "Overall, in the last 30 days, how much did these difficulties [symptoms] interfere with your life?"). This item also uses a 0–4 scale, with "0" signifying "not at all" and "4" indicating "extremely." Similar to the symptom domain scores, the symptom interference score was dichotomized into "not severe" (scores < 3) and "severe" (scores ≥ 3) groups.

Finally, symptom validity was assessed using the NSI Validity-10 scale (or "Val-10"), which is comprised of 10 infrequently endorsed items on the NSI (Vanderploeg et al., 2014). These items are summed to create a total score (range 0–40), and a cutoff of >22 has traditionally been used to reflect "symptom invalidity" (Vanderploeg et al., 2014). Other proposed Val-10 cutoffs for service members and veterans with a history of TBI include a total score of ≥ 33, ≥ 27, ≥ 26, ≥ 22, ≥ 13, and ≥ 7 (Armistead-Jehle et al., 2018; Bodapati et al., 2019; Dretsch et al., 2017; Lange et al., 2015). Symptom validity testing is used to detect "invalid response styles," with the assumption being that scoring above a certain cutoff suggests that one may be overreporting their symptoms (Vanderploeg et al., 2014). We examined all seven proposed cutoffs; for each cutoff, the Val-10 total score was dichotomized as follows: the "above SVT cutoff" group included participants with a Val-10 total score above the designated cutoff, and the "below SVT cutoff" group included participants with a Val-10 total score below the designated cutoff.

Data Analysis

Stata (Stata/MP 15.1) was used to perform all analyses. Descriptive statistics were used to characterize the overall sample, and chi-square analyses were computed to evaluate the relationship between the race/ethnicity and neurobehavioral symptom domains and symptom validity cutoff scores (i.e., the proportion of veterans who were classified in the "above SVT cutoff" group) among veterans with a CTBIE-confirmed history of TBI. Stata performs computations on all available data; thus, analyses were carried out on the total number of non-missing cases. Bonferroni correction was used to account for multiple comparisons (12 unique analyses resulted in an adjusted alpha of ∼.004). Significant omnibus tests were followed up with two-sample Z tests of proportions; for these analyses, a *p*-value of .05 was used to establish statistical significance. To better understand the significant omnibus tests, logistic regressions adjusting for sociodemographic- and injury-related variables (including age, sex, education, marital status, employment status, region of CTBIE completion, and presence of blast exposure) were conducted to ascertain the effect of racial/ethnic identity on neurobehavioral symptom domains (i.e., reporting "severe" vs. "not severe" symptoms) and symptom validity (i.e., "above SVT cutoff" or "below SVT cutoff"). Covariates were selected given prior research showing associations between TBI outcomes and sociodemographic- and injury-related variables (Brown, Kheng, Carney, Rubiano, & Puyana, 2019; Stein et al., 2016; Zeldovich et al., 2020). Odds ratios (ORs) and 95% confidence intervals (CIs) were computed and a *p*-value of .05 was used to establish statistical significance.

Results

Sample Characteristics

Of the 9,646 veterans participating in this study, 5,801 identified as White (60.1%), 1,431 as Black (14.8%), 1,365 as Hispanic (14.2%), 283 as Asian (2.9%), 272 as Multiracial (2.8%), 208 as Another Race (2.2%), 159 as American Indian or Alaska Native (1.6%), and 127 as Native Hawaiian or Other Pacific Islander (1.3%). Table 1 displays participant characteristics by racial/ethnic group. Groups differed significantly by age, sex, level of pre-military education, marital status, employment status, military branch of service, and region of CTBIE completion (*p*s < .001–.002). Of note, Asian veterans had the largest proportion of participants aged 18–29 (46.6%), whereas Multiracial veterans had the largest proportion of veterans aged 50+ (17.0%). Additionally, the sample was predominantly male, with men significantly outnumbering women across all racial/ethnic groups; however, Black veterans had the largest representation of female Veterans (13.8%).

Regarding injury characteristics (Table 1), groups differed significantly across the following variables: mechanism of injury (i.e., vehicular, fall, and injury due to blast); presence of LOC and PTA; and experiencing a TBI prior to deployment (all *p*s < .001). Blast injury was the most commonly reported mechanism of injury across all racial/ethnic groups, with White and Native Hawaiian or Other Pacific Islander veterans reporting the highest proportion of injury due to blast (78.1% and 77.2%, respectively). Multiracial and American Indian or Alaska Native veterans had the highest rates of LOC (61.8% and 61.2%, respectively) and Native Hawaiian or Other Pacific Islander veterans had the highest rates of PTA (47.7%). Finally, having a history of TBI before deployment was most often reported in Multiracial veterans (28.7%).

Neurobehavioral Symptoms

Table 2 depicts results of chi-square analyses comparing racial/ethnic groups across neurobehavioral symptoms. There were significant group differences on the vestibular, somatic/sensory, and affective symptom domains of the NSI (all *p*s < .001), but no significant group differences were observed for cognitive symptoms or symptom interference after applying a Bonferroni correction (*p*s = .012–.020). Specifically, Black veterans and Multiracial veterans endorsed severe vestibular symptoms most frequently (9.2% and 9.0%, respectively); veterans identifying as Another Race and American Indian or Alaska Native endorsed severe somatic/sensory symptoms most frequently (11.5% and 10.8%, respectively); and Black veterans endorsed severe affective symptoms most frequently (41.9%). By contrast, Asian veterans and Hispanic veterans endorsed the lowest rates of severe vestibular symptoms (5.0% and 5.1%, respectively); White veterans endorsed the lowest rates of severe somatic/sensory symptoms (4.5%); and Asian veterans endorsed the lowest rates of severe affective symptoms (23.0%).

Pairwise comparisons showed that when comparing all racial/ethnic groups to one another, there were no significant differences between groups for the vestibular and somatic/sensory domains (all *p*s > .05; see Supplementary material online, Table S3). However, there were significant differences for the affective domain. Specifically, veterans identifying as Black endorsed severe affective symptoms at a higher rate than veterans identifying as White, Hispanic, and Asian ($p \leq .001$–.025). Additionally, veterans identifying as Hispanic and Multiracial endorsed severe affective symptoms at a higher rate than Asian veterans ($p = .050$).

Table 1. Participant characteristics by racial/ethnic group[a]

Variables	White ($n = 5,801$) %	Black ($n = 1,431$) %	Hispanic ($n = 1,365$) %	Asian ($n = 283$) %	Multiracial ($n = 272$) %	Another race ($n = 208$) %	AI/AN ($n = 159$) %	NH/OPI ($n = 127$) %	p[b]	Effect Size (V)[c]
Age at CTBIE										
18–29	39.7	24.1	40.6	46.6	29.2	33.0	25.2	41.8	<.001	0.11
30–39	34.7	30.7	36.4	31.6	35.2	30.9	39.3	36.4		
40–49	17.5	32.6	18.6	16.2	18.6	25.8	23.0	16.4		
50+	8.2	12.7	4.4	5.7	17.0	10.32	12.6	5.5		
Sex										
Male	92.4	86.2	93.1	94.0	87.9	90.4	87.4	92.1	<.001	0.09
Female	7.6	13.8	6.9	6.0	12.1	9.6	12.6	7.9		
Pre-military education										
High school or less	58.9	55.3	60.9	52.5	57.0	55.9	59.2	56.1	.002	0.04
Some college	33.9	36.4	34.6	36.2	33.8	35.6	32.9	38.2		
College degree or more	7.2	8.3	4.4	11.2	9.1	8.4	7.9	5.7		
Marital status										
Single/Never married	22.3	21.3	21.3	46.1	20.3	20.7	21.4	21.3	<.001	0.06
Married or partnered	53.0	51.6	52.6	40.1	54.2	53.4	46.5	53.5		
Divorced or separated	24.2	26.5	25.9	13.1	24.7	26.0	32.1	25.2		
Widowed	0.5	0.6	0.2	0.7	0.7	0.0	0.0	0.0		
Employment status										
Employed	42.8	39.3	41.4	35.0	39.6	45.6	42.8	37.9	<.001	0.06
Unemployed	40.2	43.2	35.6	29.6	47.0	39.8	44.7	34.7		
Student	15.6	16.2	21.7	33.6	12.3	13.6	10.5	25.0		
Volunteer/homemaker	1.4	1.3	1.3	1.8	1.1	1.0	2.0	2.4		
Military branch: Air Force	6.1	3.9	3.6	3.6	6.3	3.9	6.3	7.9	.001	0.05
Military branch: Army	72.8	78.8	65.6	63.8	70.2	64.6	73.6	70.9	<.001	0.09
Military branch: Marines	19.1	11.7	26.0	23.1	20.2	27.2	15.1	17.3	<.001	0.10
Military branch: Navy	8.0	10.9	10.0	15.6	10.3	10.7	12.0	10.2	<.001	0.06
Region of CTBIE completion										
Northeast	19.9	28.2	13.9	15.6	17.7	15.9	13.8	7.1	<.001	0.15
Southeast	21.5	27.1	19.5	7.1	18.0	16.8	8.2	14.2		
Continental/Midwest	34.9	28.9	26.1	14.5	30.2	29.8	25.2	16.5		
Pacific	23.7	15.8	40.5	62.9	34.2	37.5	52.8	62.2		
MOI: bullet	4.4	4.1	3.3	1.3	2.9	3.8	5.0	4.6	.295	0.03
MOI: vehicular	26.8	30.5	29.8	21.7	29.6	32.5	26.0	28.3	.030	0.04
MOI: fall	33.1	37.6	34.4	35.5	38.2	39.4	40.8	32.7	.035	0.04
MOI: blast	78.1	71.1	75.9	74.7	69.7	74.2	72.5	77.2	<.001	0.06
LOC present										
Yes	58.4	55.8	56.0	54.0	61.8	58.7	61.2	59.0	.020	0.04
No	32.0	37.1	36.2	37.5	31.1	33.7	30.9	33.3		
Uncertain	9.6	7.1	7.8	8.5	7.1	7.6	7.9	7.7		
AOC present										
Yes	93.4	92.1	92.3	92.9	90.3	94.2	92.2	91.1	.607	0.03
No	4.8	5.4	5.7	5.6	7.8	3.7	6.5	7.3		
Uncertain	1.8	2.5	2.1	1.5	2.0	2.1	1.3	1.6		
PTA present										
Yes	41.2	36.0	36.5	28.1	35.3	41.5	35.6	47.7	<.001	0.05
No	47.4	53.0	52.3	58.9	55.9	48.7	57.6	44.9		
Uncertain	11.4	11.0	11.2	13.0	8.8	9.9	6.8	7.5		
TBI prior to deployment										
Yes	24.9	17.6	16.2	19.3	28.7	18.9	23.4	19.7	<.001	0.07
No	71.0	78.2	81.2	76.8	66.8	76.7	70.9	77.2		
Uncertain	4.2	4.2	2.6	3.9	4.5	4.4	5.7	3.2		
TBI since deployment										
Yes	11.8	11.1	10.7	8.9	14.6	11.1	9.4	11.9	.765	0.02
No	85.3	85.7	86.0	89.3	82.0	85.0	86.8	84.9		
Uncertain	2.9	3.2	3.3	1.8	3.4	3.9	3.8	3.2		

Abbreviations: AI/AN = American Indian or Alaska Native; NH/OPI = Native Hawaiian or Other Pacific Islander; CTBIE = Comprehensive Traumatic Brain Injury Evaluation; MOI = mechanism of injury; LOC = loss of consciousness; AOC = alteration of consciousness; PTA = post-traumatic amnesia; TBI = traumatic brain injury.

[a] $N = 9,646$ (White: $n = 5,801$; Black: $n = 1,431$; Hispanic: $n = 1,365$; Asian: $n = 283$; Multiracial: $n = 272$; Another Race: $n = 208$; AI/AN: $n = 159$; NH/OPI: $n = 127$); however, some variables have missing data. Percentages are calculated as a proportion of the available data. [b] Chi-square analyses were used to evaluate the association between race/ethnicity and participant characteristics; the associated p-value is reported. [c] Effect sizes are reported as Cramer's V values.

Table 2. Neurobehavioral symptom domains and symptom validity indices by racial/ethnic group[a]

Variables	White ($n = 5,801$) %	Black ($n = 1,431$) %	Hispanic ($n = 1,365$) %	Asian ($n = 283$) %	Multi-racial ($n = 272$) %	Another race ($n = 208$) %	AI/AN ($n = 159$) %	NH/OPI ($n = 127$) %	p[b]	Effect size (V)[c]
NSI symptom domains[d]										
NSI vestibular										
Severe	5.5	9.2	5.1	5.0	9.0	8.7	5.7	8.7	<.001	0.06
Not severe	94.5	90.9	94.9	95.0	91.0	91.3	94.3	91.3		
NSI somatic/sensory										
Severe	4.5	8.6	5.8	5.7	9.2	11.5	10.8	7.1	<.001	0.08
Not severe	95.5	91.4	94.2	94.4	90.8	88.5	89.2	92.9		
NSI cognitive										
Severe	28.4	32.0	27.6	21.9	32.1	30.3	29.1	24.6	.012	0.04
Not severe	71.6	68.0	72.4	78.1	67.9	69.7	70.9	75.4		
NSI affective										
Severe	33.4	41.9	35.2	23.0	38.0	35.1	38.6	30.2	<.001	0.08
Not severe	66.7	58.1	64.8	77.0	62.0	64.9	61.4	69.8		
Symptom interference										
Severe	43.6	46.8	45.0	37.4	44.4	46.9	46.3	33.1	.020	0.04
Not severe	56.4	53.2	55.0	62.6	55.6	53.1	53.7	66.9		
NSI Val-10 indices[e]										
Val-10 ≥ 33										
Below SVT cutoff	98.8	98.0	98.3	98.6	97.8	95.2	97.5	96.0	<.001	0.05
Above SVT cutoff	1.2	2.0	1.7	1.4	2.3	4.8	2.6	4.0		
Val-10 ≥ 27										
Below SVT cutoff	93.2	88.8	91.8	93.6	88.8	87.0	87.9	91.3	<.001	0.07
Above SVT cutoff	6.8	11.2	8.2	6.4	11.2	13.0	12.1	8.7		
Val-10 ≥ 26										
Below SVT cutoff	91.4	86.3	90.3	91.8	87.3	85.5	87.3	88.1	<.001	0.07
Above SVT cutoff	8.6	13.7	9.7	8.2	12.7	14.5	12.7	11.9		
Val-10 > 22										
Below SVT cutoff	84.4	77.0	83.0	87.6	78.7	77.8	80.9	81.8	<.001	0.08
Above SVT cutoff	15.6	23.0	17.0	12.4	21.4	22.2	19.1	18.3		
Val-10 ≥ 22										
Below SVT cutoff	81.0	73.3	79.3	86.2	75.7	73.4	75.8	80.2	<.001	0.08
Above SVT cutoff	19.0	26.7	20.7	13.8	24.3	26.6	24.2	19.8		
Val-10 ≥ 13										
Below SVT Cutoff	42.5	36.4	42.6	52.1	35.2	35.3	34.4	45.2	<.001	0.07
Above SVT Cutoff	57.5	63.6	57.4	47.9	64.8	64.7	65.6	54.8		
Val-10 ≥ 7										
Below SVT cutoff	15.6	12.6	16.8	25.2	13.1	15.9	11.5	23.0	<.001	0.06
Above SVT cutoff	84.4	87.4	83.2	74.8	86.9	84.1	88.5	77.0		

Abbreviations: AI/AN = American Indian or Alaska Native; NH/OPI = Native Hawaiian or Other Pacific Islander; NSI = Neurobehavioral Symptom Inventory; Val-10 = Validity-10; SVT = symptom validity test.

[a]$N = 9,646$ (White: $n = 5,801$; Black: $n = 1,431$; Hispanic: $n = 1,365$; Asian: $n = 283$; Multiracial: $n = 272$; Another Race: $n = 208$; AI/AN: $n = 159$; NH/OPI: $n = 127$); however, some variables have missing data. Percentages are calculated as a proportion of the available data. [b]Chi-square analyses were used to evaluate the association between race/ethnicity and neurobehavioral symptoms and symptom validity; the associated p-value is reported. Note, Bonferroni correction was used to account for multiple comparisons; 12 unique analyses resulted in an adjusted alpha of ~0.004. [c]Effect sizes are reported as Cramer's V values. [d]NSI symptom cluster variables range from 0 to 4 (0 = no symptoms, 4 = very severe symptoms); scores were dichotomized into "severe" (scaled score ≥ 3) and "not severe" (scaled score < 3) groups, with the former reflecting clinically significant symptoms. The proportions (or percentage) of participants endorsing "severe" and "not severe" symptoms are reported in the table. [e]Each Val-10 index was dichotomized using previously established SVT cutoffs; the "below SVT cutoff" group included participants with a Val-10 total score below the cutoff and the "above SVT cutoff" group included participants with a Val-10 total score above the cutoff.

Table 3 presents ORs and 95% CIs for each racial/ethnic group comparison evaluating the odds of reporting "severe" neurobehavioral symptoms, adjusting for age, sex, education, marital status, employment status, region of CTBIE completion, and presence of blast exposure. When comparing all racial/ethnic groups to one another (28 possible comparisons), there were 2 significant group comparisons for the vestibular symptoms (ORs = 0.54–1.43), 5 significant comparisons for somatic/sensory symptoms (ORs = 1.35–2.05), and 10 significant comparisons for affective symptoms (ORs = 0.46–2.43). See Table 3 for full results.

Table 3. ORs[a] evaluating NSI symptom clusters by racial/ethnic group[b]

	White OR (CI)	Black OR (CI)	Hispanic OR (CI)	Asian OR (CI)	Multiracial OR (CI)	Another race OR (CI)	AI/AN OR (CI)	NH/OPI OR (CI)
NSI vestibular								
White	—							
Black	**1.43**** (1.13, 1.81)	—						
Hispanic	0.83 (0.62, 1.12)	**0.54**** (0.38, 0.78)	—					
Asian	1.08 (0.61, 1.93)	0.79 (0.41, 1.52)	1.44 (0.72, 2.89)	—				
Multiracial	1.17 (0.72, 1.91)	0.75 (0.45, 1.27)	1.27 (0.71, 2.27)	0.89 (0.35, 2.23)	—			
Another race	1.22 (0.70, 2.11)	0.82 (0.46, 1.47)	1.34 (0.71, 2.53)	0.99 (0.38, 2.61)	1.17 (0.55, 2.49)	—		
AI/AN	0.80 (0.37, 1.74)	0.58 (0.26, 1.33)	0.79 (0.33, 1.85)	0.88 (0.28, 2.75)	0.94 (0.34, 2.56)	0.88 (0.30, 2.55)	—	
NH/OPI	0.78 (0.31, 1.95)	0.57 (0.21, 1.52)	0.78 (0.28, 2.20)	0.53 (0.15, 1.89)	0.89 (0.30, 2.65)	0.97 (0.31, 3.04)	1.22 (0.28. 5.26)	—
NSI somatic/sensory								
White	—							
Black	**1.51**** (1.17, 1.95)	—						
Hispanic	**1.35*** (1.02, 1.80)	0.77 (0.54, 1.09)	—					
Asian	**1.91*** (1.12, 3.27)	1.22 (0.66, 2.26)	1.21 (0.66, 2.22)	—				
Multiracial	1.33 (0.80, 2.21)	0.74 (0.43, 1.28)	0.87 (0.49, 1.54)	0.65 (0.27, 1.52)	—			
Another race	**2.01**** (1.22, 3.29)	1.16 (0.68, 1.97)	1.27 (0.73, 2.20)	1.04 (0.44, 2.47)	1.05 (0.53, 2.11)	—		
AI/AN	**2.05*** (1.14, 3.67)	1.15 (0.61, 2.17)	1.39 (0.74, 2.61)	1.12 (0.45, 2.75)	1.73 (0.76, 3.92)	1.32 (0.59, 2.94)	—	
NH/OPI	1.40 (0.59, 3.30)	0.83 (0.33, 2.08)	0.89 (0.36, 2.18)	0.76 (0.23, 2.49)	1.11 (0.36, 3.40)	0.87 (0.29, 2.65)	2.06 (0.64, 6.67)	—
NSI affective								
White	—							
Black	**1.21**** (1.07, 1.37)	—						
Hispanic	1.11 (0.98, 1.27)	**0.82*** (0.69, 0.98)	—					
Asian	**0.63**** (0.46, 0.87)	**0.46***** (0.32, 0.66)	**0.52***** (0.37, 0.74)	—				
Multiracial	1.03 (0.80, 1.34)	**0.74*** (0.56, 0.97)	0.89 (0.67, 1.18)	1.23 (0.77, 1.97)	—			
Another race	0.91 (0.68, 1.22)	**0.67*** (0.49, 0.92)	0.74 (0.54, 1.02)	1.03 (0.62, 1.70)	1.29 (0.85, 1.95)	—		
AI/AN	1.08 (0.76, 1.53)	0.82 (0.56, 1.20)	0.99 (0.68, 1.43)	1.52 (0.89, 2.61)	1.35 (0.83, 2.19)	1.53 (0.92, 2.56)	—	
NH/OPI	0.71 (0.46, 1.10)	**0.54*** (0.34, 0.87)	0.67 (0.42, 1.05)	0.91 (0.50, 1.67)	**0.53*** (0.29, 0.96)	0.79 (0.43, 1.45)	**2.43**** (1.25, 4.74)	—

Abbreviations: NSI = Neurobehavioral Symptom Inventory; OR = odds ratios; CI = 95% confidence interval; AI/AN = American Indian or Alaska Native; NH/OPI = Native Hawaiian or Other Pacific Islander.

[a]Logistic regression analyses examined the association between racial/ethnic identity and the odds of reporting "severe" neurobehavioral symptoms, adjusting for sociodemographic- and injury-related characteristics. Each symptom domain was dichotomized using scaled scores; the "severe" group included participants with a scaled score ≥3, and the "not severe" group included participants with a scaled score <3. [b]The racial/ethnic group in each column is the reference group and the OR (CI) applies to the racial/ethnic group in each row. Significant values are denoted by bold font. *$p < .05$. **$p \leq .01$. ***$p \leq .001$.

Symptom Validity

The results of chi-square analyses comparing racial/ethnic groups across symptom validity cutoffs are shown in Table 2. We evaluated seven different Val-10 cutoffs (≥33, ≥27, ≥26, >22, ≥22, ≥13, and ≥7). As expected, we found that as the cutoff score was lowered, rates of scoring above the cutoff increased across all racial/ethnic groups. Moreover, when evaluating

the proportion of veterans who were classified as "above SVT cutoff" across racial/ethnic groups, we found significant group differences on all seven cutoffs (all *p*s < .001). For example, when examining the cutoff score of ≥27, veterans identifying as Another Race had the highest rates of scoring above the cutoff (13.0%); for the cutoff of >22 (i.e., the originally established Val-10 score), veterans identifying as Black had the highest rates (23.0%); and for the cutoff of ≥13, veterans identifying as Multiracial had the highest rates (65.6%). By contrast, Asian veterans had the lowest rates of scoring above the cutoff of ≥27 (6.4%), >22 (12.4%), and ≥13 (47.9%).

Pairwise comparisons were conducted on select Val-10 cutoff scores (≥27, >22, and ≥13); results revealed that when comparing all racial/ethnic groups to one another, there were no significant differences between groups for the cutoff score of ≥27 (all *p*s < .05; see Supplementary material online, Table S4). When evaluating the cutoff of >22, results showed that Veterans identifying as Black had a higher rate of being classified as "above SVT cutoff" relative to White veterans ($p = .003$). Finally, when using the cutoff of ≥13, there were several significant differences. Specifically, veterans identifying as Black had a higher rate of being classified as "above SVT cutoff" than veterans identifying as White and Hispanic ($p \leq .001$–$.010$). Additionally, veterans identifying as Asian had a lower rate of being classified as "above SVT cutoff" relative to veterans identifying as White, Black, Hispanic, Multiracial, Another Race, and American Indian or Alaska Native ($p \leq .001$–$.039$).

Table 4 presents ORs and 95% CIs for each racial/ethnic group comparison evaluating the odds of scoring above select Val-10 cutoff scores (≥ 27, >22, and ≥13), adjusting for age, sex, education, marital status, employment status, region of CTBIE completion, and presence of blast exposure. When comparing all racial/ethnic groups to one another (28 possible comparisons), there were 3 significant group comparisons for scoring above the cutoff of ≥27 (ORs = 1.42–3.00), 1 significant comparison for scoring above the cutoff of >22 (OR = 1.19), and 5 significant comparisons for scoring above the cutoff of ≥13 (ORs = 0.64–2.00). See Table 4 for full results.

Discussion

The overall intent of this study was to begin exploring the nuances of racial/ethnic differences in important TBI outcomes (i.e., neurobehavioral symptoms and symptom validity) by utilizing a large sample of military veterans representing a wide range of racial/ethnic identities. Our results showed racial/ethnic group differences across neurobehavioral symptom domains and symptom validity (i.e., in the proportion of veterans who were classified as falling above the SVT cutoff) among veterans with a history of TBI. Results indicate that the SVT cutoffs, which were developed on racially homogenous samples, warrant close consideration before being used on racially/ethnically diverse samples within clinical and research contexts. Our findings highlight the ongoing need for future work that considers how distinct cultural factors relate to symptom reporting patterns following TBI among veterans.

With regard to neurobehavioral symptom domains, we found racial/ethnic group differences in symptom reporting across the frequency of severe vestibular, somatic/sensory, and affective symptoms. By contrast, no group differences were observed for cognitive symptoms or symptom interference. When evaluating pairwise comparisons, significant differences were only observed for the affective symptom domain. Specifically, severe affective symptoms were reported by Black veterans at a greater rate than White, Hispanic, and Asian Veterans. Finally, adjusted models showed that the greatest number of racial/ethnic differences was found for the affective symptom domain, with fewer group differences found for endorsement of severe vestibular and somatic/sensory symptoms.

Our results are broadly consistent with some prior TBI research showing racial/ethnic differences in neurobehavioral symptom reporting, mental health outcomes, and neurological/physical sequelae following injury (Arango-Lasprilla et al., 2012; Hart et al., 2014; Perrin et al., 2014; Schwab et al., 2017; Swan et al., 2018). In particular, our finding that the affective symptom domain showed the greatest number of racial/ethnic differences is not surprising, given prior TBI research (for a review, see Arango-Lasprilla & Kreutzer, 2010). For example, Hart and colleagues (2014) found racial/ethnic differences in psychiatric symptom improvement following TBI, with Black participants improving the least and Hispanic participants improving the most. Moreover, Perrin and colleagues (2014) showed that Black and Hispanic participants had higher post-injury depressive symptoms than White and Asian/Pacific Islander participants, and Black participants had higher anxiety symptoms than all other racial/ethnic groups. More research is needed to understand and contextualize the differences observed in the present study, but as evinced in the broader mental health literature, racial/ethnic differences in symptom reporting have been related to complex interactions between sociocultural factors, including education, socioeconomic status, discrimination, acculturation, social support networks, access to and quality of health care, trust in the health care system, provider discrimination, symptom interpretation, and format of symptom reporting (Abrams & Mehta, 2019; Arango-Lasprilla & Kreutzer, 2010; Cokley, Hall-Clark, & Hicks, 2011; Grandner et al., 2013; Prieto, McNeill, Walls, & Gómez, 2001; Shim et al., 2014). These factors may also independently influence or exacerbate symptoms. Further understanding these factors in the context of military TBI could contribute to our understanding of health disparities in this population and inform culturally sensitive services.

Table 4. ORs[a] evaluating NSI Val-10 cutoffs across racial/ethnic groups[b]

	White OR (CI)	Black OR (CI)	Hispanic OR (CI)	Asian OR (CI)	Multiracial OR (CI)	Another race OR (CI)	AI/AN OR (CI)	NH/OPI OR (CI)
Val-10 ≥ 27								
White	—							
Black	**1.42*** (1.14, 1.76)	—						
Hispanic	1.21 (0.95, 1.54)	0.77 (0.57, 1.04)	—					
Asian	1.28 (0.78, 2.12)	1.02 (0.58, 1.82)	0.88 (0.50, 1.54)	—				
Multiracial	0.96 (0.60, 1.55)	0.63 (0.38, 1.04)	0.69 (0.41, 1.18)	0.65 (0.28, 1.52)	—			
Another race	1.53 (0.96, 2.42)	0.98 (0.60, 1.60)	1.07 (0.64, 1.78)	1.16 (0.52, 2.61)	1.00 (0.52, 1.93)	—		
AI/AN	**1.72*** (1.02, 2.90)	1.18 (0.67, 2.08)	1.27 (0.73, 2.24)	1.47 (0.63, 3.44)	1.89 (0.88, 4.08)	1.37 (0.65, 2.89)	—	
NH/OPI	0.79 (0.34, 1.85)	0.69 (0.28, 1.71)	0.57 (0.23, 1.39)	0.55 (0.17, 1.76)	1.25 (0.44, 3.56)	0.84 (0.30, 2.33)	**3.00*** (1.01, 9.01)	—
Val-10 > 22								
White	—							
Black	**1.19*** (1.01, 1.39)	—						
Hispanic	1.14 (0.96, 1.35)	0.81 (0.65, 1.01)	—					
Asian	0.93 (0.64, 1.37)	0.69 (0.44, 1.07)	0.76 (0.50, 1.17)	—				
Multiracial	1.07 (0.77, 1.47)	0.76 (0.54, 1.08)	0.83 (0.58, 1.19)	1.08 (0.59, 1.96)	—			
Another race	1.33 (0.94, 1.87)	0.96 (0.67, 1.40)	0.98 (0.67, 1.43)	1.38 (0.74, 2.55)	1.04 (0.63, 1.71)	—		
AI/AN	1.11 (0.72, 1.71)	0.84 (0.53, 1.34)	0.84 (0.53, 1.34)	1.23 (0.62, 2.45)	1.18 (0.64, 2.15)	1.03 (0.55, 1.92)	—	
NH/OPI	1.12 (0.67, 1.87)	0.95 (0.54, 1.67)	0.95 (0.55, 1.65)	1.13 (0.54, 2.35)	1.22 (0.62, 2.40)	1.20 (0.59, 2.45)	1.04 (0.47, 2.26)	—
Val-10 ≥ 13								
White	—							
Black	**0.88*** (0.77, 0.99)	—						
Hispanic	0.96 (0.84, 1.09)	0.88 (0.73, 1.05)	—					
Asian	**0.75*** (0.58, 0.97)	**0.64**** (0.47, 0.87)	**0.65**** (0.48, 0.87)	—				
Multiracial	1.02 (0.80, 1.31)	0.94 (0.71, 1.24)	0.93 (0.70, 1.24)	1.05 (0.69, 1.60)	—			
Another race	0.97 (0.73, 1.27)	0.87 (0.64, 1.18)	0.86 (0.63, 1.17)	1.06 (0.69, 1.63)	1.48 (0.98, 2.24)	—		
AI/AN	1.07 (0.76, 1.51)	1.00 (0.69, 1.44)	1.05 (0.73, 1.52)	1.53 (0.94, 2.49)	1.40 (0.85, 2.28)	1.50 (0.90, 2.48)	—	
NH/OPI	0.88 (0.60, 1.30)	0.87 (0.57, 1.33)	0.83 (0.55, 1.24)	1.00 (0.60, 1.66)	0.93 (0.55, 1.58)	1.04 (0.61, 1.78)	**2.00*** (1.06, 3.75)	—

Abbreviations: NSI = Neurobehavioral Symptom Inventory; Val-10 = Validity-10; OR = odds ratios; CI = 95% confidence interval AI/AN = American Indian or Alaska Native; NH/OPI = Native Hawaiian or Other Pacific Islander.

[a]Logistic regression analyses examined the association between racial/ethnic identity and the odds of being classified into the "above SVT cutoff" group, adjusting for sociodemographic- and injury-related characteristics. Each Val-10 index was dichotomized using previously established SVT cutoffs; the "below SVT cutoff" group included participants with a Val-10 total score below the cutoff and the "above SVT cutoff" group included participants with a Val-10 total score above the cutoff. [b]The racial/ethnic group in each column is the reference group and the OR (CI) applies to the racial/ethnic group in each row. Significant values are denoted by bold font. $^{*}p < .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

Another notable finding to emerge in the present study was the significant group differences observed across all symptom validity cutoff scores examined (i.e., in the proportion of veterans who were classified in the "above SVT cutoff" group). By examining various cutoff scores, our data showed that as the SVT threshold was lowered, more racial/ethnic disparities were

observed. Additionally, when evaluating pairwise comparisons for select Val-10 cutoff scores (≥ 27, >22, and ≥13), significant differences were found using the cutoff scores of >22 and ≥13, and when adjusting for sociodemographic- and injury-related characteristics, the greatest number of racial/ethnic differences was observed for the cutoff of ≥13. These SVT findings are particularly salient to clinical settings and have important implications—namely, our data suggest that universally applying a Val-10 cutoff (e.g., >22) across racially/ethnically diverse veterans is likely not a valid indicator of symptom validity. As such, we do not recommend utilizing symptom validity cutoff criteria that were largely developed in racially homogenous samples on individuals who were not adequately reflected in those samples. Furthermore, we emphasize that these symptom validity cutoff criteria should not be used to make determinations about care for minoritized groups.

To our knowledge, no existing studies have investigated racial/ethnic differences on any of the empirically derived Val-10 cutoffs. There are, however, published studies examining racial/ethnic differences on performance validity testing (PVT). Although PVT and SVT measure unique constructs, the PVT literature, albeit sparse, has shown some racial/ethnic differences on PVT performance (Braun, Fountain-Zaragoza, Halliday, & Horner, 2021). The personality assessment literature has also evaluated cross-cultural differences, with a recent systematic review highlighting the lack of measurement invariance across cultural/ethnic groups for various personality measures (Dong & Dumas, 2020). Finally, it has long been established that cultural factors influence neurocognitive test performance (Heaton, Miller, Taylor, & Grant, 2004; Manly & Echemendia, 2007), and it is possible that similar factors, such as acculturation, language of the questionnaire, and stereotype threat, also play a role in patterns of symptom reporting. Future work will need to directly assess these factors and determine the extent to which other intervening factors, such as cultural differences in symptom interpretation/reporting and method of data collection (e.g., self-report, interview), may be contributing to whether an individual falls above or below Val-10 cutoff criteria.

Limitations

Building on the MVP recruitment efforts that aimed and succeeded in recruiting racially/ethnically diverse veterans, this study was the first to evaluate clinical outcomes among military veterans following TBI across eight racial/ethnic groups. Nonetheless, this study has limitations that warrant mention. First, our findings were based on existing clinical data collected from the VA's EHR. Therefore, it is possible that there were some inconsistencies or inaccuracies in the clinical data we evaluated. We also focused exclusively on self-reported NSI data collected as part of the CTBIE. However, given prior research showing that the method used to gather symptom information (e.g., self-report, interview) influences outcome (Iverson, Brooks, Ashton, & Lange, 2010; Kondiles, Starr, Larson, & Zollman, 2015; Krol, Mrazik, Naidu, Brooks, & Iverson, 2011), it will be necessary for future studies to consider method of data collection as well as one's openness to report symptoms. Furthermore, evaluating a criterion measure, such as the Minnesota Multiphasic Personality Inventory and/or the Personality Assessment Inventory, is critical to validate the Val-10 findings and would significantly aid in the clinical interpretation of our findings. It is also important to appreciate that although the explicit purpose of this study was to explore racial/ethnic differences in neurobehavioral symptom reporting and symptom validity, further research is needed to determine the mechanisms that account for the observed between-group differences. Future studies could focus on examining the role of culture in neurobehavioral symptom reporting or investigating how other sociodemographic- and injury-related variables, such as age, gender, socioeconomic status, level of service connection, geographic region, and total number of TBIs, influence these relationships.

Another important caveat to be mindful of when interpreting study results is that we used pre-determined racial/ethnic categories based on information available within the EHR and excluded individuals with unknown or missing racial/ethnic data. Future research is needed to better understand what factors contribute to these unknown or missing data (e.g., did some veterans choose not to answer for a particular reason, or did veterans feel they were not adequately represented in the available racial/ethnic categories). Furthermore, it is important to acknowledge that there is variability within any one of the eight racial/ethnic identities utilized in this study, and the use of broad labels (e.g., "Hispanic") can hide or mask important within-group variation in life experiences and cultural identity, which may be important to consider. Relatedly, we did not address other aspects of intersectionality which will be important to consider in future research. In the present study, we explicitly focused on racial/ethnic differences in symptom reporting and symptom validity; however, we recognize that other aspects of one's identity (e.g., sex, gender, age, social class, ability, and/or disability status) may also influence symptom endorsement patterns. More research is needed to better understand how these characteristics and group memberships intersect to influence neurobehavioral symptoms in this population.

Other study limitations relate to generalizability. We specifically evaluated post-deployed Iraq- and Afghanistan-era veterans, the majority of whom identified as male; thus, it is unclear how our results would generalize to other populations (e.g., athletes, civilians, veterans who served in other eras, and female and nonbinary veterans). We also examined the neurobehavioral symptoms categorically by comparing severe (i.e., "clinically significant") symptom presentation on the NSI to non-severe symptom presentation. This approach yielded clinically relevant results, but further research should examine whether our results

would hold if different cutoffs were used to classify "clinically significant" symptoms. Finally, investigating measurement invariance, or measurement equivalence, of the NSI and Val-10 is critical. For example, confirming that the NSI symptom domains are equivalent, or have the same meaning, across different racial/ethnic groups would enhance confidence in the ongoing use and widespread application of these symptom domains.

Conclusion

Our findings on racial/ethnic differences in TBI-related outcomes among veterans are particularly important, given the growing emphasis on patient-centered care for TBI within the VHA (The Management and Rehabilitation of Post-Acute Mild Traumatic Brain Injury Work Group, 2021). Indeed, the most recent clinical practice guidelines encourage clinicians to be mindful of their patients' racial/ethnic identities and to provide culturally appropriate care (The Management and Rehabilitation of Post-Acute Mild Traumatic Brain Injury Work Group, 2021). Based on our findings, it will be necessary to validate the NSI and Val-10 for use across racially/ethnically diverse groups of veterans and to determine the most appropriate cutoff scores to use for the Val-10 in racially/ethnically diverse veterans. It will also be necessary for future studies to examine racial/ethnic differences in referrals for TBI services, service utilization, and treatment outcomes, as this would be clinically informative by providing metrics on existing health disparities to guide future health equity initiatives within the VHA. Moreover, future studies could consider how factors such as discrimination and systemic racism contribute to racial/ethnic differences in TBI-related outcomes. Ultimately, such research could inform culturally relevant, patient-centered interventions and care for racially/ethnically diverse veterans with a history of TBI. One of the VHA's missions is to provide equitable, accessible health care (VHA Office of Health Equity, 2021). Understanding racial/ethnic differences in how veterans experience TBIs and how these differences manifest in health care referrals and outcomes are critical steps in reducing health care disparities and improving care for all veterans.

Supplementary material

Supplementary material is available at *Archives of Clinical Neuropsychology* online.

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Data Availability Statement

The datasets generated and/or analyzed during the current study are not publicly available due to MVP restrictions; however, the corresponding author is willing to engage with reasonable requests and answer questions about the present study.

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Conflict of Interest

None declared.

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