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Research Article

Neuropsychiatric symptoms after moderate-to-severe traumatic brain injury in Vietnam: Assessment, prevalence, and impact on caregivers

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Abstract

Objective: Neuropsychiatric symptoms (NPSs) after moderate-to-severe traumatic brain injury (TBI) have been well documented in WEIRD (Western, educated, industrialized, rich, and democratic) populations. In non-WEIRD populations, such as Vietnam, however, patients with TBI clinically remain uninvestigated with potential neuropsychiatric disorders, limiting on-time critical interventions. This study aims to (1) adapt the Vietnamese Neuropsychiatric Inventory (V-NPI), (2) examine NPSs after moderate-to-severe TBI and (3) evaluate their impact on caregiver burden and well-being in Vietnam. **Method:** Caregivers of seventy-five patients with TBI completed the V-NPI, and other behavior, mood, and caregiver burden scales. **Results:** Our findings demonstrated good internal consistency, convergent validity, and structural validity of the V-NPI. Caregivers reported that 78.7% of patients with TBI had at least three symptoms and 16.0% had more than seven. Behavioral and mood symptoms were more prevalent (ranging from 44.00% to 82.67% and from 46.67% to 66.67%, respectively) and severe in the TBI group. Importantly, NPSs in patients with TBI uniquely predicted 55.95% and 33.98% of caregiver burden and psychological well-being, respectively. **Conclusion:** This study reveals the first evidence for the presence and severity of NPSs after TBI in Vietnam, highlighting an urgent need for greater awareness and clinical assessment of these symptoms in clinical practice. The adapted V-NPI can serve as a useful tool to facilitate such assessments and interventions. In addition, given the significant impact of NPS on caregiver burden and well-being, psychosocial support for caregivers should be established.

Keywords: Neuropsychiatric Inventory Questionnaire; cross-culture; behavioral symptoms; mood; brain damage; Vietnam

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Introduction

Vietnam is a developing country with a rising incidence of neurological disorders that have significant detrimental consequences (Carr et al., 2018). Among those, moderate-to-severe traumatic brain injury (TBI) is reported to be a highly prevalent outcome of traffic accidents (Vu et al., 2019). This is primarily due to the widespread use of two-wheeled vehicles, coupled with a lack of fastidious adherence to safety measures and compliance with traffic rules among the majority of the population (Ngo et al., 2012; Tran et al., 2022). As physical impairments can be noticed immediately in patients with TBI (Sherer et al., 1998), assessment and rehabilitation plans for TBI survivors solely focus on these deficits in Vietnam. This results in the typical under-recognition of the presence and impact of neuropsychological sequelae, including neuropsychiatric problems, in clinical practice, causing delayed diagnosis and interventions.

Over recent decades, research that studies the outcomes for patients with moderate-to-severe TBI in developed countries, particularly in Western populations are prominent. In these populations, it has been documented that patients with TBI typically experience a vast array of neurological deficits, not only in cognitive and physical domains but also in neuropsychiatric symptoms (NPSs) (Draper & Ponsford, 2008; Arango & Kreutzer, 2010; Griffen & Hanks, 2014). Despite the recognition that neuropsychiatric symptoms (NPSs) after TBI mainly arise from neuropathology and so should be generalized to cultures other than the West, empirical evidence from Asian populations, including Vietnamese, is very limited. To date, only apathy has been directly examined in Vietnamese individuals with moderate-to-severe TBI (Quang, McDonald et al., 2022). Importantly, initial evidence has suggested that cultural factors, such as family roles and expectations, personal perspectives, and cultural values, may

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contribute to the way in which NPSs are reported (Quang, Sin et al., 2022). They reported that when Vietnamese and North American healthy samples were compared, the Vietnamese were found to report higher levels of apathy symptoms, leading to higher cutoff scores on apathy scales for this population. However, how this effect generalizes to other NPSs and whether standardized measures are still able to accurately capture NPS in Vietnamese patients with TBI remains unclear.

Worldwide, given the loss of abilities and functions associated with TBI, patients with TBI depend heavily on their caregivers on a daily basis (Kreitzer et al., 2018). In this context, previous studies have indicated that NPSs are the primary cause of caregiver burden. Compared to non-TBI groups, caregivers of patients with TBI, including familial and paid caregivers, experienced higher levels of care burden and stress (Basu & Mukhopadhyay, 2022; Curtiss et al., 2000), a higher risk of developing depression and anxiety (Rivera et al., 2007; Tay & Kong, 2020), lower life satisfaction, mood swings, and negative thoughts (Anderson et al., 2002; Kaewphinit et al., 2022). In Asia, where cultural norms prioritize familial value and the outsourcing of caregiving duties is avoided, it is common for family members to bear the caregiving responsibilities for patients with neurological disorders, including TBI (Basu & Mukhopadhyay, 2022; Devi et al., 2020, Kaewphinit et al., 2022). Moreover, due to high costs or the scarcity of care services, families are frequently responsible for rehabilitation and recovery following hospital discharge (Pekerti et al., 2017). In addition, paying for intense, long-term care for patients with TBI heavily impacts the financial status of households, as both patients with TBI and their familial caregivers cannot acquire sufficient income through working (Saban et al., 2016). Compared to men, women are more typically impacted and passively assigned to provide care for their family members as society's expectations view them as primary familial caregivers (Sharma et al., 2016). As a result, a significant proportion of patients' caregivers are reported to be female (Lai, 2012), typically serving as spouses or mothers of the affected individuals (Nam & Park, 2017). Together, this evidence suggests an elevation in care burden and distress in caregivers of people with TBI, particularly women, especially in the Vietnamese cultural context. However, to our knowledge, there has been no research on NPS after TBI in Vietnam so the impact of these symptoms on patients and their caregivers is underexplored.

The present study aimed to assess the presence and impact of NPS after moderate-to-severe TBI in Vietnam. Given that there is no current validated measurement of NPS and caregiving burden in Vietnam, we adapted the Vietnamese Neuropsychiatric Inventory and caregiving burden measures and examined their psychometric properties. Following this, we used the validated tools to investigate the frequency and severity of NPS in patients with moderate-to-severe TBI. We hypothesized that NPS, especially behavioral problems, would be prevalent among Vietnamese individuals with TBI and that their severity would be greater than the healthy comparison group. Finally, we assessed the impact of NPS on caregiver burden and psychological well-being, with a hypothesis that these symptoms would significantly impact the burden and well-being of their caregivers.

Methods

Participants

Seventy-five patients with moderate-to-severe TBI and their major caregivers participated in the study. We conducted a thorough search within the patient dataset at the Department of Neurosurgery, Cho Ray Hospital, Southern Vietnam. Considering the established connections between NPS and impairment to the frontal brain network (Robert, 2020), this search was performed utilizing the keyword "frontal contusion" and encompassed hospital admissions recorded from 2016 to 2019, with the patients' time of injury ranging from 9 to 51 months upon participating in this study. The full recruitment procedure was fully reported in one previous study by Quang, McDonald, et al. (2022). Inclusion criteria were: (a) aged from 18 to 65 at the time of the TBI, (b) Glasgow Coma Scale Score <13 (moderate-to-severe coma) administered within 24 hours of injury, (c) brain scan evidence documented by computed tomography. Subjects were excluded if they had (a) a history of alcohol or drug abuse, (b) psychiatric/neurological conditions (e.g., schizophrenia, psychosis, or anxiety disorder) and/or prior to the moderate-to-severe brain injuries, (c) vision or hearing problems that could not be corrected (e.g., permanent loss of vision or hearing), (d) movement restriction (e.g., not being able to sit), and (e) limited Vietnamese language proficiency. Table 1 depicts basic demographic information of patients with moderate-to-severe TBI and their caregivers.

Table 1. Demographic characteristics

Characteristic	TBI ($N = 75$)	Informant ($N = 75$)
Biological sex, male	88%	40%
Age, years	33.91 ± 11.80 (18–65)	41.52 ± 13.38 (21–72)
• 18–39 years	70.67%	
• 40–59 years	25.33%	
• 60–65 years	4%	
Education, years	8.99 ± 3.99 (0–16)	8.69 ± 4.68 (0–16)
• ≤12 years	86.67%	
• >12 years	13.33%	
Time since injury, months	27.17 ± 1.29 (9–51)	
Causes of trauma		
• Traffic accident	92%	
• Work accident	3%	
• Self-fall	4%	
• Beaten	1%	
Specific lesions of frontal lobe concussions		
• Lateral		
○ Left	25.3%	
○ Right	26.7%	
• Bilateral	28%	
• Complicated cases	20%	
GCS within 24 hours of accident	8.48 ± .29 (3–12)	
Moderate TBI (%)	52.00%	
Severe TBI (%)	48.00%	

Note. Most informants are family members such as spouses, parents, siblings, and adult children. Values are mean ± standard deviation (range: lowest-highest). Moderate TBI = GCS score of 9–12, severe TBI = GCS score of 8 or less. Frequency statistics are used for biological sex, age (in years), and education level (in years). TBI = traumatic brain injury; GCS = Glasgow Coma Scale.

For a control group, we recruited seventy-two healthy participants from the community in Ho Chi Minh City and surrounding areas. Selection criteria for the control group were the same as the TBI group, except that people with a TBI condition were additionally excluded. Given the TBI group's higher male representation and lower education levels, twenty participants among the healthy control group were then selected to best match the demographic characteristics of the 54 individuals with TBI, including biological sex, age, and education level (Table 2, all $p > .05$).

All participants underwent the Montreal Cognitive Assessment (MoCA) to briefly assess cognitive functions (Nasreddine et al.,

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Table 2. Demographic and cognitive characteristics of patients with traumatic brain injury and healthy individuals

Characteristic	TBI ($N = 54$)	HC ($N = 20$)	r	Statistic	p value
Biological sex, male	83.3%	65%	−.196	2.90	.089
Age, years	32.24 ± 11.66 (19–64)	32.00 ± 13.71 (18–60)	−.090	476.50	.439
• 18–39 years	81.49%	75%			
• 40–59 years	14.81%	20%			
• ≥60 years	3.70%	5%			
Education, years	10.80 ± 2.98 (6–16)	12.00 ± 2.67 (5–16)	−.215	389.50	.065
• ≤12 years	81.48%	55%			
• >12 years	18.52%	45%			
GCS within 24 hours since injury	8.06 ± 2.38 (3–12)				
• Moderate TBI (%)	44.00%				
• Severe TBI (%)	56.00%				
Time since injury (months)	26.19 ± 11.08 (10–51)				
MoCA total scores	19.70 ± 4.75 (8–29)	25.47 ± 2.32 (21–29)		137.50	<.001
• Memory subscale	5.80 ± 4.07 (0–14)	9.84 ± 3.49 (0–15)		242.50	.001
• Executive functions subscale	8.67 ± 2.50 (2–13)	11.05 ± 1.35 (8–13)		198.50	<.001
• Attention/concentration subscale	13.68 ± 3.61 (3–18)	16.79 ± 1.18 (14–18)		237.00	<.001
• Language subscale	3.85 ± 1.25 (0–6)	4.79 ± 1.03 (3–6)		298.00	.005
• Visuospatial skills subscale	5.50 ± 1.13 (2–7)	6.79 ± .41 (6–7)		147.50	<.001
• Orientation subscale	5.15 ± 1.31 (0–6)	6.00 ± .00		304.00	.001

Note. Values are mean ± standard deviation (range: lowest-highest). Moderate TBI = GCS score of 9–12, severe TBI = GCS score of 8 or less. A Chi-square test was used for biological sex, Mann–Whitney U tests were used for the remaining variables. TBI = traumatic brain injury; HC = healthy controls; MoCA = Montreal Cognitive Assessment; GCS = Glasgow Coma Scale.

2005). The Vietnamese version of the MoCA was taken from the official MoCA website: https://www.mocatest.org/ with the maximum total score for MoCA is 30 (test-takers received one extra point if their education level was less than 12 years) and higher scores indicating better cognitive performance (Quang et al., 2023). The total score and subdomain scores of the MoCA were significantly lower for patients with TBI than the control group (all p values ≤ .005, Table 2).

The research was completed in accordance with the Helsinki Declaration. All participants provided written informed consent. The UNSW Human Ethics Committee and Cho Ray Hospital's Ethics Committee for Biomedical Research approved the study. Each patient was supported with VND560.000 (∼USD 24) as reimbursement for medical examinations, and healthy controls received either course credits or VND200,000 (∼USD 10) for their time participating in this study.

Measure and procedures

Adaptation procedure for the Neuropsychiatric Inventory

Neuropsychiatric Inventory (NPI). The NPI, brief version (Cummings et al., 1994) is a screening tool for NPS commonly observed in neurological conditions, including TBI (Kilmer et al., 2006). On the scale, caregivers/close others of both individuals with TBI and those in the HC group identified whether each of 12 NPS (hallucinations, delusions, agitation/aggression, dysphoria/depression, anxiety, irritability, disinhibition, euphoria, apathy, aberrant motor behavior, sleep/nighttime behavior change, and appetite/eating change) were present. The caregivers responded with either "Yes" or "No" to determine the presence for each of NPS. If the answer is "Yes", they then rated the severity of the symptom (how it affects the patient/ healthy individual): 1 = "mild" (noticeable, but not a significant change), 2 = "moderate" (significant, but not a dramatic change) and 3 = "severe" (very marked or prominent, a dramatic change). Total score ranges from 0 to 30. The brief NPI has been demonstrated to be a reliable ($\alpha = .783$) and valid measure. The scale is highly correlated with the full NPI ($r = .730$) (Musa et al., 2017).

Adaptation procedure. The V-NPI adaptation process followed recommended guidelines (Guillemin et al., 1993; Sousa & Rojjanasrirat, 2011):

1. The English scale was translated into Vietnamese by a researcher of native Vietnamese origin, currently working in an Australian tertiary institution who was knowledgeable in both the language and the theoretical background in the field.
2. The Vietnamese versions were translated back into English by two independent professionals who are bilingual, bicultural, and unaware of the original scale. Any disagreements between the translated and decompiled versions were revised and resolved by the translators.
3. Five Vietnamese volunteers were invited to explain the meaning of each item. In cases where the interpretation does not reflect the original content, further refinement was carried out.
4. A preliminary version of the scale was read by 20 other volunteers. Follow-up interviews were conducted to collect information on the readability and cultural relevance of the scale. Any comments raised by respondents have been considered for the final version.
5. The final sample of 75 informants of people with moderate-to-severe TBI and 20 close relatives or family members of healthy participants completed the final V-NPI.

Measures for assessing convergent validity of the V-NPI

The Vietnamese Frontal Systems Behavior Scale (V-FrSBe) (Grace et al., 2001; Quang, Sin, et al., 2022) measures behavioral changes associated with frontal lobe damage. The V-FrSBe is a 46-item rating scale, with three subscales: apathy (14 items, e.g., "*has difficulty starting an activity*"), disinhibition (15 items, e.g., "*makes inappropriate sexual comments and advances*"), and executive dysfunction (17 items, e.g., "*pays attention, concentrates even when there are distractions*"). The psychometric properties of the V-FrSBe apathy and disinhibition subscales have been reported for TBI populations, demonstrating good reliability ($\omega_t > .70$) and validity (Quang, Sin, et al., 2022). In this study, the V-FrSBe was used to measure convergent validity with the V-NPI. Caregivers of

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patients with TBI rated each V-FrSBE item on a 5-point scale, with the possible total score ranging from 46 to 230.

The Vietnamese Depression Anxiety Stress Scales-21 (V-DASS-21) (Lovibond & Lovibond, 1995; Tran et al., 2013) is a commonly used measure of emotional states (depression, anxiety, and stress). The scale has been applied to clinical populations in Vietnam and showed good internal consistency ($\alpha = .88$) (Tran et al., 2013). Here, the V-DASS- 21_Patient was also used to evaluate the convergent validity of the V-NPI. Patients with TBI rated each item to evaluate their own mood symptoms on a 4-point scale.

Measures of caregivers' burden and psychological well-being

The Caregiver Strain Index (CSI) (Robinson, 1983) is used to identify strain of caregivers, their ability for caring, and areas where support may be needed (e.g., *"it is a financial strain"*). The CSI has been found to be highly reliable ($\alpha > .70$) (Robinson, 1983; Ugur & Fadiloglu, 2013) and correlated with patient characteristics and subjective perception of the caregiver-caring relationship and emotional health (Robinson, 1983). Caregivers completed the questionnaire with a "yes" or "no" answer for each item. The maximum score is 13.

The Zarit Burden Interview (ZBI) (Zarit et al., 1980) is used to assess caregiver psychological burden (e.g., "*Do you feel stressed between caring for your relatives and trying to meet other responsibilities for your family or work?*"). ZBI is a reliable burden measure ($\alpha > .90$) (Chattat et al., 2011; Ko et al., 2008; Seng et al., 2010) and found to be strongly correlated with depressive mood of the caregivers ($r = .59$) (Hébert et al., 2000). Each item on the interview is a statement that the caregiver is asked to endorse using a 5-point scale, maximum score = 88. The V-CSI and V-ZBI were adapted based on the same procedure for V-NPI. The association between the two attested to their convergent validity given no other carer-burden instruments are currently validated in Vietnam. Caregivers additionally completed the V-DASS-21_Caregiver (in which they rated their own mood for themselves) for the assessment of caregiver psychological well-being.

Data analysis

SPSS-version 26 was used for all statistical analyses, with $p < .05$. Normality of distribution and homogeneity of variances were explored using Kolmogorov–Smirnov tests and Levene's tests, respectively. Depending on whether the data meet the parametric assumptions, independent sample t tests or Mann–Whitney tests are conducted to compare continuous variables (e.g. age or NPS severity) between the patient and the control group. Descriptive statistics were generated for demographic and test variables.

To examine psychometric properties of the Vietnamese scales that had not been validated in TBI populations, Cronbach's alpha was used to test the internal consistency reliability. Spearman's correlation coefficients were performed between the V-NPI, V-FrSBe and V-DASS-21_Patient scores and between V-ZBI and V-CSI. A correlation coefficient value of >.7 (or <−.7) suggests a strong correlation, from .3 to .6 (or −.3 and −.6) shows a moderate correlation, and between 0 and .3 (or 0 and −.3) suggests a weak correlation (Akoglu, 2018). A principal component analysis (PCA) with the Oblimin rotation method was conducted to examine the main components onto which symptoms of the NPI loaded. The correlation matrix was used for component extraction based on Kaiser and Cattell criteria, while Kaiser-Meyer-Olkin and Bartlett test of sphericity confirmed the adequacy of the sample for PCA (Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .753 and Bartlett's Test of Sphericity ($p < .001$)). Items <.3 on any component were considered as low loadings on that component.

To determine whether individuals with TBI had greater levels of NPS than neurologically healthy people, a two-way ANOVA was performed comparing TBI vs. healthy controls (between groups) on the 12 different symptom types of the NPI (within groups), controlling for gender and education.

To assess the impact of NPS after moderate-to-severe TBI on carer burden, two multiple regression models were performed on data from the TBI group, with caregiver burden composite scores ([CSI % scores + ZBI % scores]/2) and V-DASS-21_Caregiver total scores as the dependent variable for each analysis. Predictive factors included demographic variables (age, sex, and education), general cognition (measured via the MoCA-total scores), and NPI scores, which were divided into 3 components according to PCA results: Component 1, Component 2, and Component 3.

Results

Psychometric properties of Vietnamese Questionnaire Reliability

All of the Vietnamese questionnaires used in this study demonstrated acceptable to high levels of internal consistency, with reliability coefficients ranging from .786 to .923. The V-ZBI showed the highest alpha value ($\alpha = .923$), followed closely by the V-DASS-21_Caregiver ($\alpha = .917$) and the V-DASS-21_Patient ($\alpha = .899$). The V-CSI, V-NPI, and V-FrSBe also demonstrated excellent internal consistency, with $\alpha = .874$, .812, and .786, respectively.

Validity

Spearman's correlations revealed a strong and positive correlation between the V-NPI and the V-FrSBe ($\rho(75) = .722$, $p = .002$; Figure 1A), as well as between the V-NPI and the V-DASS-21_Patient ($\rho(75) = .715$, $p < .001$; Figure 1B). For caregiver burden measures, a moderate and positive correlation was observed between the V-ZBI and V-CSI ($\rho(75) = .564$, $p < .001$; Figure 1C).

Principal component analysis

The PCA identified three components, together explaining 55.09% of the variance (Table 3). Component 1 demonstrated significant loadings for behavioral problems including disinhibition, apathy, motor disturbance, irritability, nighttime behavior, and elation. Component 2 showed significant loadings for anxiety, eating problems, and delusions. Lastly, Component 3 showed significant loadings for depression, hallucinations, and agitation.

Frequency and severity of neuropsychiatric symptoms after TBI in Vietnam

Figure 2 depicts the frequency of NPS after moderate-to-severe TBI. 21.3% of the Vietnamese patients with moderate-to-severe TBI exhibited none to two NPS, whereas 62.7% had three to seven symptoms and 16.0% had more than seven symptoms (Figure 3A).

Across 12 symptoms measured by the NPI, behavior deficits were highly prevalent, with irritability occurring in 82.67% of patients with TBI, appetite/eating problems in 65.33%, nighttime behaviors in 65.33%, disinhibition in 62.67%, apathy in 61.33%, agitation in 54.67%, and motor disturbance in 44.00%. Affective symptoms were also common, with anxiety being present in

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Table 3. Factor loadings of the Neuropsychiatric Inventory items ($N = 75$)

	Component		
Symptoms	1	2	3
Disinhibition	0.777		
Apathy	0.705		
Motor disturbance	0.692		
Irritability	0.653		0.386
Nighttime behavior	0.626		
Elation	0.609		
Anxiety		0.792	
Appetite		0.691	
Delusion		0.661	
Depression			0.825
Hallucination			0.686
Agitation			0.529
Eigenvalue	1.198		

66.67%, elation/euphoria in 60.00%, and depression in 46.67%. Last, psychotic symptoms were less observed by caregivers, with delusion being exhibited in 41.33% and hallucination in 36.00%.

A two-way ANCOVA (controlling for sex and education) examining group status (TBI vs HC) and NPS symptoms showed that the TBI group, overall, had significantly greater NPS symptoms compared to the control group ($F(1, 70) = 11.660$, $p = .001$, $\eta_p^2 = .143$). There was no main effect of symptom type ($F(11, 770) = .963$, $p = .479$, $\eta_p^2 = .014$) and no NPS × group interaction ($F(8.125, 568.744) = 1.057$, $p = .392$, $\eta_p^2 = .015$). Education had a significant impact on NPS ($F(1, 70) = 7.928$, $p = .006$, $\eta_p^2 = .102$) whereas sex did not ($F(1, 70) = -1.263$, $p = .265$, $\eta_p^2 = .018$).

Impact of NPI on caregivers' burden and caregivers' well-being

Table 4 shows factors predicting caregivers' burden and caregivers' psychological well-being. The multiple regression model with caregivers' burden as the outcome variable was significant, ($F(7, 74) = 12.15$, $p < .001$, $f^2 = 1.27$), accounting for 55.95% of the total variance. NPS Components 1, 2, and MoCA-total scores were significant factors, accounting for 10.82%, 3.28%, and 10.56% of the total variance in caregivers' burden, respectively. For caregivers' psychological well-being, a significant multiple regression model was observed, ($F(7, 74) = 4.932$, $p < .001$, $f^2 = 0.52$), accounting for 33.98% of the total variance. The severity of NPS on the V-NPI was the only significant factor in Components 1 and 3, accounting for 7.02% and 7.95% of the total variance in caregivers' psychological well-being.

Discussion

While NPS are well-recognized after traumatic brain injury (TBI) in WEIRD (Western, educated, industrialized, rich, and democratic) populations, they are often overlooked and their management is inadequate in non-WEIRD populations. Therefore, our study first aimed to translate and adapt the NPI questionnaire in Vietnam using a standardized procedure; and to provide empirical evidence of the presence and impact of NPS after TBI on the patients' caregivers. Our results confirm the high prevalence of NPS in this population, with a particular emphasis on behavioral and mood symptoms. Importantly, our study highlights the direct influence of NPS on the burden and psychological well-being of caregivers.

Psychometric properties of the V-NPI

The Vietnamese version of the NPI questionnaires (V-NPI) demonstrated a good measurement of NPS in the TBI population. Firstly, items on the V-NPI were highly correlated with one another, evident in the excellent internal consistency. In addition, the V-NPI had good convergent validity as it showed expected concordances with validated measures of behavioral and emotional states (i.e., the V-FrSBe and V-DASS-21_Patient). These findings are consistent with other studies on the NPI in different languages, such as Spanish (Castaño Monsalve et al., 2012), Italy (Ciurli et al., 2011), Chinese (Leung et al., 2001), and Korean (Kim et al, 2016).

Our PCA also identified three NPI components: behavioral (Component 1), affective (Components 2 and 3), and psychiatric (Components 2 and 3). While the behavioral component was clearly shown, the affective and psychotic symptoms seemed mixed in Component 2 and Component 3, which differed from our expectations. A previous study by Aalten et al. (2003) identified three factors on the NPI: (1) mood/apathy: which includes depression, apathy, nighttime behavior disturbances, and appetite and eating abnormalities; (2) psychosis: which includes delusions, hallucinations, and anxiety; (3) hyperactivity: which includes agitation, euphoria, irritability, disinhibition, and aberrant motor

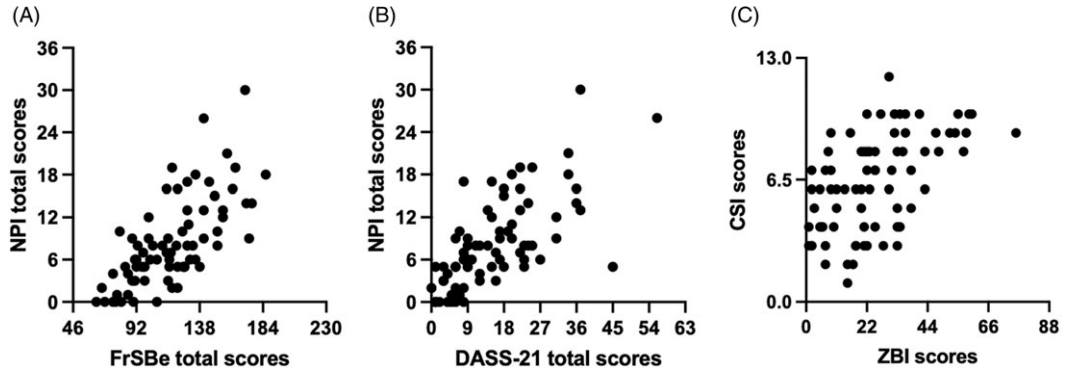

Figure 1. Spearman's correlations for the relationship between the Vietnamese scales ($N = 75$). (A) A strong and positive correlation between the Neuropsychiatric Inventory and Frontal Systems Behavior Scale. (B) Similarly, a strong and positive correlation between the Neuropsychiatric Inventory and the Depression Anxiety Stress Scales-21. (C) A moderate and positive correlation between the Zarit Burden Interview and the Caregiver Strain Index. *Note.* NPI = Neuropsychiatric Inventory questionnaire; FrSBe = Frontal Systems Behavior Scale; DASS-21 = Depression Anxiety Stress Scales-21 (Patient); ZBI = Zarit Burden Interview; CSI = Caregiver Strain Index.

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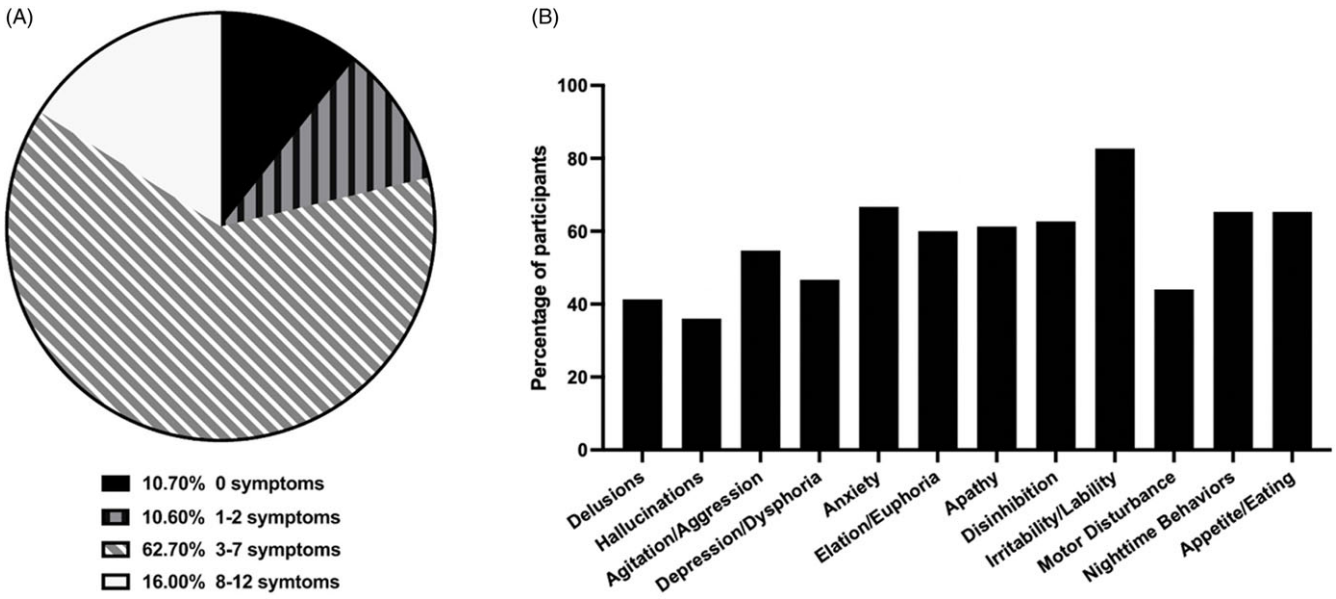

Figure 2. Frequency of neuropsychiatric symptoms after traumatic brain injury in Vietnam ($N = 75$). (A) Proportions of patients with TBI who had none to two, three to seven, and more than seven neuropsychiatric symptoms. (B) Percentages of people who presented with each of the neuropsychiatric symptoms on the Neuropsychiatric Inventory.

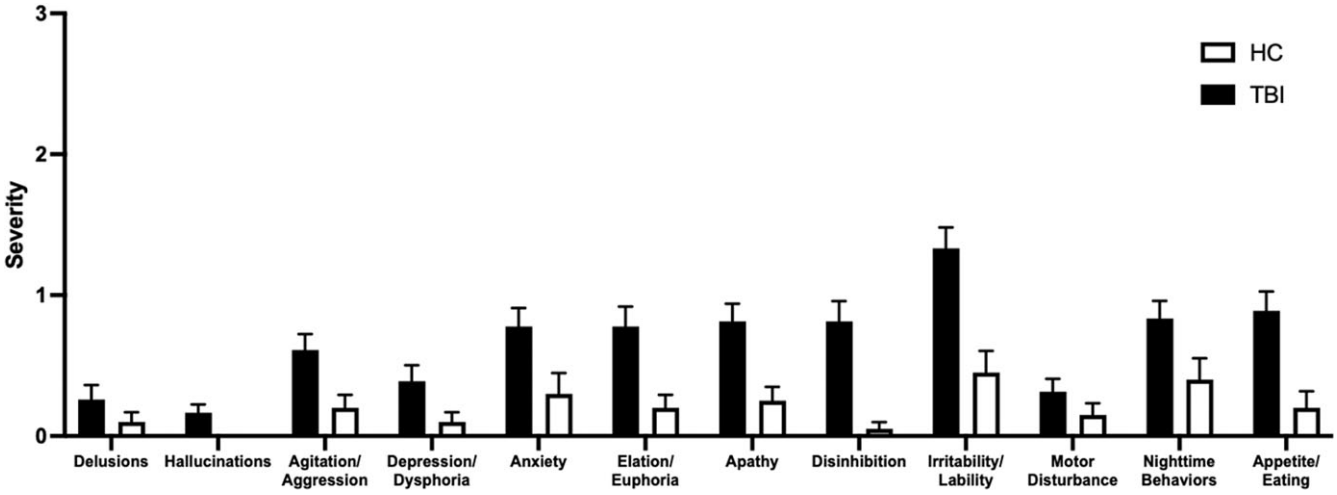

Figure 3. Comparison of individual symptom severity Neuropsychiatric Inventory between people with moderate-to-severe traumatic brain injury ($N = 54$) and healthy controls ($N = 20$). *Note.* TBI = traumatic brain injury, HC = healthy controls.

behavior. They found that the psychosis factor was associated with more severe total behavioral problems, and the symptoms of aberrant motor behavior, nighttime behavior disturbances, and anxiety had high loadings across multiple factors and were difficult to attribute to a single factor. Our findings showed a similar result to Aalten et al.'s (2003), suggesting that NPI has a good detection and clear component of behavioral symptoms, and an unclear component of non-behavioral symptoms.

Prevalence and severity of neuropsychiatric symptoms after TBI in Vietnam

Drawn from a representative sample in Vietnam in terms of demographic and clinical profiles of moderate-to-severe TBI, our results showed that 78.7% of Vietnamese patients with TBI have at least three NPS, of which 16% experienced more than seven symptoms. The finding supports previous empirical data showing that NPS occurs at a high frequency in patients with TBI. Specifically, Ciurli et al. (2011) reported that at least one of the 12 NPS was found in 78% of the Italian TBI population, and Castaño Monsalve et al. (2012) reported 92.5% of Spanish patients with TBI presented NPS.

Among these NPS, behavioral and affective symptoms in Vietnamese patients were commonly reported, even at a higher prevalence rate than the existing literature in other populations. Irritability was found in 82.67% of our sample of patients with TBI, higher than from 40% to 70% as demonstrated in Italian and English people (Ciurli et al., 2011; Rao et al., 2007). Eating problems were reported by 65.33% of our patients, which is higher than the approximately 30% reported in the literature (Ciurli et al.,

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Table 4. Factors contributing to caregivers' burden and caregivers' psychological well-being ($N = 75$)

	Caregivers' burden				Caregivers' psychological well-being			
Predictor	*B*	*SE*	*β*	*p*	*B*	*SE*	*β*	*p*
(Constant)	**75.313**	**14.785**		**<.001**	**28.458**	**7.453**		**<.001**
Component 1	**15.757**	**3.881**	**.390**	**<.001**	**5.221**	**1.956**	**.314**	**.010**
Component 2	**7.726**	**3.463**	**.216**	**.029**	.754	1.746	.051	.667
Component 3	5.544	5.007	.103	.272	**7.166**	**2.524**	**.324**	**.006**
MoCA_total	**−2.094**	**.522**	**−.403**	**<.001**	−.060	.263	−.028	.821
Biological sex	2.819	7.827	.033	.720	−1.102	3.946	−.031	.781
Age (years)	−.351	.219	−.149	.113	.046	.110	.047	.678
Education (years)	.815	.721	.117	.262	−.091	.363	−.032	.802

Note. Bold indicates significant predictors with $p < .05$. The demographics in the predictor columns refer to patients with TBI.

2011; Devi et al., 2020). Similarly, 62.57% and 54.67% of our patients were reported experiencing disinhibition and agitation, respectively, higher than 4–10% and 20–40% reported in existing evidence (Devi et al., 2020; Nicholl & LaFrance, 2009; de Guise et al., 2005). Elation/euphoria was found in 60%, much higher than existing results in approximately 13% (Ciurli et al., 2011). Only anxiety (66.67%) and apathy (49.1%) were reported at similar rates to findings from other studies: 11–70% and 46.4–71.1%, respectively (Ciurli et al., 2011). Taken together, our study generally showed the possibility of a greater occurrence of behavioral and affective NPS in Vietnamese people with TBI than observed in the WEIRD populations. Another explanation for this effect is the variability of semantic constructs across languages and cultures that could not be completely avoided during translation and adaptation of existing measures.

Impact of NPS on caregiver burden and well-being

This study sheds light on the impact of NPS severity in Vietnamese patients with TBI on their primary caregivers. The results indicate that such prevalence predicted 55.95% of caregiver burden and 33.98% of caregiver well-being. Interestingly, we have found the behavior and affective symptoms within NPS each accounted for caregiver burden. These findings are consistent with previous research that has linked sudden behavior changes following TBI (e.g., apathy, irritability, appetite, disinhibition, and agitation) (Devi et al., 2020; Machamer et al., 2002), or affective symptoms (Bamatraf et al., 2020; Kaewphinit et al., 2022, Simpson et al., 2020) to a lack of immediate coping mechanisms for caregivers.

Furthermore, caregivers and family members often struggle to comprehend and accept the changes in the patient's behavior, as they are frequently unprepared and untrained to care for traumatic injuries (Clark et al., 2020; Kjeldgaard et al., 2023). Our study confirmed that sudden changes in behaviors, anxiety, and delusions contribute to caregiver psychological well-being. This issue is particularly prevalent in Vietnam and other non-WEIRD populations where caregiving responsibilities typically fall on family members (Basu & Mukhopadhyay, 2022; Nguyen et al., 2021). As a result, caregivers often lack the necessary skills to manage TBI rehabilitation and provide adequate care. Moreover, limited resources and support coupled with the caregiver's responsibilities put them at risk of neglecting their self-care, leading to feelings of isolation and fear of being the sole person responsible for the patient's well-being (Liu et al., 2017, Malec et al., 2017). Of note, the result regarding gender of the major caregiver was in line with expectations that the majority of caregivers were women (Sharma et al., 2016). Overall, this study emphasizes the need for better caregiver training, support, and resources, when NPS occur after TBI, especially in non-WEIRD populations, to alleviate caregiver burden and improve patient outcomes.

Research and clinical implications

It is crucial to utilize validated measurements to identify NPS in clinical practice, as it would enable more accurate assessments of neuropsychological symptoms after TBI and facilitate immediate and effective treatment for patients. V-NPI offers a validated neuropsychological screening tool that Vietnamese clinicians are encouraged to use in clinical settings. Though our validated version of V-NPI has taken the semantic constructs of the language into account, it is important to note that broader cultural differences may have impacted how NPI measured symptoms across our sample group. Not only NPS but other standard neuropsychological terminology is not widely used or understood in Vietnam. For example, depression is usually mistaken for fatigue, stress, and anxiety. Given the lack of concrete understanding of such terminology in Vietnamese, the V-NPI was tailored to best-fit knowledge in Vietnamese social culture. This imprecision could possibly explain the high symptom prevalence in Vietnam compared to other investigated populations. It would be interesting to investigate whether the NPSs, in particular, show different patterns as measured by the V-NPI compared to other adapted and validated versions in other countries as well as the original version.

Combining our results and existing research, it is evident that NPSs affect caretakers, posing urgent attention and intervention. In Vietnam, social assistance and support aid are not widely accessible and are insufficient for patients and caregivers to be financially stable during home-based rehabilitation. Thus, psycho-educational programs, such as free public training courses could significantly help caregivers to gain coping skills while providing care to their loved ones (Bayen et al., 2016). Moreover, psychological consultation sessions would benefit both patients and caregivers. These sessions will help caregivers to discuss their psychological concerns, resulting in reduction of mood symptoms, as well as facilitate the reduction of caregiver burden (Bayen et al., 2016). Lastly, it is vital to improve public awareness of the neuropsychiatric consequences post-TBI in Vietnam, requiring addressing current societal stigma and training for healthcare professionals.

Limitations and future directions

This study has several limitations. First, our database for the TBI group was collected from Cho Ray Hospital, a preeminent medical institution in the heart of the country's largest city, which has the sole facility that accommodates moderate-to-severe TBI cases,

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invariably receiving patient transfers from surrounding areas within southern Vietnam. Future studies that assess cultural factors of NPS should be conducted in northern Vietnam with an expanded sample size to provide a deeper insight into potential cultural variations of the population. It is important to underscore, however, that we do not expect significant variations in the severity and prevalence of NPI within the TBI group in the Vietnam population since our database encompasses a diverse group of participants from minor and major provinces and cities spanning middle to southern Vietnam.

Secondly, our healthy control group is relatively small ($n = 20$) compared to the TBI group ($n = 54$). This reflected the logistical challenge of recruiting sufficient individuals from a similar demographic profile to that of the TBI group, i.e. high male representation and low education levels. While acknowledging the need for future improvements, including a larger and better-matched control group, we believe that our findings are valuable for addressing our central questions regarding the measurement of NPS in TBI. A third limitation arises from our focus on patients with documented lesions in the frontal lobes, with or without lesions elsewhere. In previous research focusing on NPS among patients with general TBI, Ciurli et al. (2011) and Devi et al. (2020) reported a lower prevalence of all reported NPS compared to our current findings, although these studies were not conducted in Vietnam. This suggests that NPS may be less common and exhibit greater variations among individuals with general TBI than in those with specifically documented frontal lobe contusion TBI. Thus, caution should be taken when interpreting our results.

Lastly, given that the NPS does not only affect caregivers but also the patients with TBI themselves, future investigations in Vietnam could explore to what extent these symptoms influence TBI survivors' basic living activity, employment, and social connections. Furthermore, it is still unclear how cultural factors such as spiritual and religious beliefs modulate the presentation and impact of NPS after TBI in Vietnam. While neural and cognitive mechanisms are still an important aspect to explore (Quang, Kumfor et al., 2022), cross-cultural differences at the individual level, such as family roles and expectations, and religious beliefs, can contribute to different representations of NPS. For example, based on our clinical observations, when a Vietnamese individual shows hallucination symptoms, they have a tendency to seek religious explanations rather than scientific evidence. Studies focusing on cultural variations will provide important insights for effective interventions of NPS in Vietnam.

Conclusion

This current study is one of the first investigations targeting the impact of moderate-to-severe patients with TBI and their caregivers in Vietnam. The study found that NPSs are highly prevalent among patients with TBI in the region, and these symptoms have significant impacts on the burden and mental health of their caregivers. These findings highlight the need for focused therapies and support programs for caregivers of patients with TBI with NPS to reduce their burden and improve psychosocial outcomes. Furthermore, the study lays the groundwork for future research into the NPS among the neurological populations in Vietnam, which has the potential to inform the development of evidence-based interventions and to improve the lives of affected individuals and their families.

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