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**INFORMATION PAPER**

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MCMR-DCV  
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SUBJECT: Neurobehavioral Symptom Inventory (NSI): Recommendations for Scoring and Serial Administration for Concussion Health Care Outcomes Standardization

1. PURPOSE

The purpose of this paper is to provide a survey of the literature and best practices in scoring and measurement frequency for the NSI, one of two core measures selected for concussion health care outcomes in the Military Health System. This review provides the basis for recommendations for standardization by the Office of Outcomes and Assessments (OOA) at the Defense and Veterans Brain Injury Center (DVBIC). The paper was disseminated to stakeholders to initiate discussion on the use of the NSI in serial assessment for health care outcomes so as to develop consensus for a quad service solution to standardized implementation.

2. BACKGROUND

The NSI is a self-report questionnaire initially published in the *Journal of Head Trauma Rehabilitation* (Cicerone and Kalmar, 1995) that was developed in an attempt to delineate the interrelationships between symptoms in patients presenting with post-concussive syndrome. The NSI consists of 22 non-specific complaints commonly reported after concussion and is used by clinicians to quantify traumatic brain injury (TBI) symptom severity and select symptoms for treatment. The NSI asks the patient to rate each of the symptoms according to how much the symptom has disturbed him/her using a five point scale. Patient ratings are based on descriptions of the frequency of the symptom, the extent to which the symptom disrupts the patient's activities, and the patient's perceived need for help with the symptom. The items comprising the NSI are displayed in in Table 1.

Table 1: NSI Symptoms

Item Number	Symptom
1	Feeling Dizzy
2	Loss of Balance
3	Poor coordination, clumsy
4	Headaches
5	Nausea
6	Vision problems, blurring, trouble seeing
7	Sensitivity to light
8	Hearing difficulty
9	Sensitivity to noise
10	Numbness or tingling on parts of my body
11	Change in taste and/or smell
12	Loss of appetite or increased appetite
13	Poor concentration, can't pay attention, easily distracted
14	Forgetfulness, can't remember things
15	Difficulty making decisions
16	Slowed thinking, difficulty getting organized, can't finish things
17	Fatigue, loss of energy, getting tired easily
18	Difficulty falling or staying asleep
19	Feeling anxious or tense
20	Feeling depressed or sad
21	Irritability, easily annoyed
22	Poor frustration tolerance, feeling easily overwhelmed by things

The NSI is widely used in the Department of Defense (DoD) for the evaluation of post-concussive symptoms in service members (SMs). In addition, the Department of Veterans Affairs (VA) uses the NSI in its comprehensive TBI evaluation. The NSI was recently selected by stakeholders in the DoD and VA as one of the core outcome measures for concussion health care.

There is an emerging literature on the psychometric properties of the NSI including content validation with the warfighter population. King et al. (2012) studied the NSI's item properties, internal consistency, and external validity in combat veterans (mean time since injury = 41 months) using data collected at VA medical centers and a VA outpatient clinic. An item analysis demonstrated the internal consistency of the NSI items and that NSI scores correlated highly with clinician confirmed TBI as well as measures of affective disturbance. The NSI is currently undergoing further content and construct validation in the DoD to FDA standards (Miller, personal communication).

### 3. OVERVIEW

Although the NSI is recommended as an outcome measure for post-concussive symptoms by the NINDS Common Data Elements working group (Wilde, 2010) and is widely used in the DoD for evaluation of mild traumatic brain injury (m/TBI), little empirical data is available regarding its use for the assessment of health care effectiveness. Given that the NSI was selected by stakeholders as a core measure for concussion health care outcome, implementation needs to be standardized regarding scoring and frequency of administration so that feedback to providers about patient status is presented consistently and data can be aggregated across settings.

A review of the available literature and survey of clinical practices provides recommendations presented in this paper. Evidence indicates that the NSI is well suited to serial administration and supports scoring NSI clusters of symptoms referred to as factors (somatosensory, cognitive, affective, and vestibular). Additional scoring methods for the initial (following diagnosis) and subsequent concussion visits and metrics for aggregated data are presented as best practice recommendations.

### 4. APPROACHES TO SCORING THE NSI

#### A. Total Score

Although Cicerone and Kalmar initially did not report a total NSI score, clinicians often compute a total NSI score to quantify post-concussive symptom severity. In this scoring approach, the 22 individual symptoms items are weighted equally. However, research shows that even healthy, non-concussed individuals endorse some symptomatology on the NSI with the base rates varying by symptom (Iverson and Lange, 2003). In the absence of comprehensive normative data for the NSI, clinicians lack the necessary information to know whether a given total NSI score reflects elevated symptom reporting. Normative data using a sample of more than 3,000 Florida National Guard including a small sample of service members with combat related mTBI was recently published (Soble, Silva, and Vanderploeg, 2014). This data sample represents a first step in providing clinicians norms to assist with interpretation of NSI scores for military personnel.

#### B. Individual Symptom Change

The other approach used by DoD and VA clinicians in interpreting the NSI is to examine items scored at moderate severity or higher, an approach that also has been used in research studies with active duty and veteran populations. Iverson et al. (2011) using the same VA sample as Meterkro dichotomized the severity ratings on the NSI symptom items as severe/very severe and none/mild/moderate as a marker of clinically relevant symptoms and outcomes for symptom severity in patients with deployment-related mTBI. In a study of troops returning from Afghanistan and Iraq, Schwab et al. (2007) found a moderate association between the number of TBI-related problems reported on

a TBI screening interview and the number of moderate/severe post concussive symptoms reported on the NSI. The prevalence of having three or more moderate/severe post-concussive symptoms was higher among those with self-reported TBI-related problems than those not reporting TBI-related problems.

Good clinical practice involves monitoring patient change with specific interventions and courses of treatment. The ability to detect change includes evidence that the instrument is equally sensitive to gains and losses in the measurement concept and to change at all points within the entire range expected for the clinical population (FDA, 2009). There are no evidence based standards for what constitutes clinically significant change on the NSI. For a similar self-report measure, the 17 item Post Traumatic Stress Disorder Checklist (PCL), the VA National Center for PTSD recommends five points as a threshold for determining whether an individual has responded to treatment and 10 points as a minimum threshold for determining whether the improvement is clinically meaningful. In clinical trials with hyperbaric oxygen for persisting post-concussion symptoms, the DoD proposed that a responder be defined as an individual experiencing a minimum of 20% score improvement from baseline. Based on this a priori standard, the following descriptors were developed: modest change – five point reductions, moderate change – 10 point reduction, marked change – 15 point reduction (Miller, 2011).

### C. Factor Scores

There is a growing evidence base on the factor structure of the NSI although this recent research has not generally been incorporated by clinicians in scoring the NSI. Cicerone and Kalmar (1995) subjected the NSI responses by their sample to cluster analysis. Four domain clusters emerged: somatic, cognitive, affective, and sensory. Five symptoms including headaches and difficulty falling asleep or staying asleep were solitary symptoms and did not fit in any factor. There is data to suggest that as more of these factor scores reach clinically meaningful levels (defined as mean scores >2.0), there is a greater likelihood of co-morbid conditions such as depression and anxiety. This relationship is most apparent in relation to ratings on the Somatic factor (Cicerone, personal communication, 2014).

Benge, Pastorek, & Thornton (2009) evaluated 345 records of OEF/OIF veterans (96% male, mean age = 30) seen for TBI evaluation by a multidisciplinary polytrauma team at a northwestern VA hospital. Results of the initial analysis revealed a factor structure that was difficult to interpret and dissimilar from the civilian findings of Cicerone and Kalmar. Further analysis revealed significant overlap between items on the PCL-C and somatic symptoms on the NSI with post-traumatic stress disorder (PTSD) explaining a significant amount of variance in responses to the NSI, particularly for cognitive and affective complaints. After controlling for this variance, a six factor model emerged to

include cognitive, vestibular disturbance, mood disturbance, and sensory complaints/sleep disturbance, and two factors that could not be clearly identified.

Caplan et al (2010) conducted exploratory factor analysis of the NSI on 2,420 active duty Army soldiers on a non-clinical sample in which 41% reported a history of mTBI. Confirmatory factor analysis was conducted on a separate sample of 4,244 active duty Army soldiers. Results supported two and three factor models as well as a nine factor model constructed to represent a combination of the four factors identified by Cicerone and Kalmar plus the five items unassigned in their cluster analysis. Given relatively little difference between the fit indices generated by the three models, Caplan and his colleagues endorsed a three factor model consisting of affective, cognitive, and somatic/sensory factors as having the best fit for parsimony.

Meterko et al (2012) analyzed the factor structure of the NSI on a large national sample of VA patients, deployed to OEF/OIF, using confirmatory factor analyses and a random split-sample design. Exploratory factor analysis of the sample yielded credible three and four factor models although the four factor model fit the data marginally better and was preferred by the authors for considerations of interpretability and clinical utility. The four factors were somatosensory, affective, cognitive, and vestibular. Two items, hearing difficulties and change in appetite, did not fit any of the factors. The four factor item analysis is shown in Table 2.

Table 2: Meterko et al., 2012, Four Factor Structure of the NSI

	<b>Somatosensory</b>	<b>Affective</b>	<b>Cognitive</b>	<b>Vestibular</b>
<b>Number of Items</b>	7	6	4	3
<b>Item Numbers</b>	4, 5, 6, 7, 9, 10, 11	17, 18, 19, 20, 21, 22	13, 14, 15, 16	1, 2, 3

Vanderploeg et al. (2013) evaluated and compared the existing NSI factor structure models to determine best fit using two samples: a non-clinical sample of active members of the Florida National Guard (n=3,098) and a clinical sample from the national VA (n=48,175) centralized database who had completed the TBI clinical reminder screener and the VA Comprehensive TBI Evaluation. Further analyses were conducted to compare the factor structures for those deployed and not deployed in the National Guard sample and between those with a confirmed history of TBI on clinical evaluation and those determined not to have sustained a TBI within the VA sample. These findings extended Meterko et al. (2012) findings of a four factor model as having the best fit for both DoD and VA samples and across deployed and non-deployed and clinical and non-clinical subsamples.

## 5. OFFICE OF OUTCOMES AND ASSESSMENT SCORING RECOMMENDATIONS

For clinician feedback on individual patient scores, it is recommended that the following scores be computed for the initial visit:

- number of symptoms of moderate, severe, and very severe intensity and a list of the specific symptoms in each of these rating categories
- scores for somatosensory, affective, cognitive, and vestibular factors as identified by Meterko (2012) and confirmed by Vanderploeg (2013); scores will be displayed with the numerator showing the patient's score and the denominator showing the highest score possible for the factor
- comparison of baseline total and factor scores to demographic matched healthy active duty SMs (Soble et al., 2014)

For follow-up visits, the following scores are recommended:

- change in individual symptom scores of two or more points in a positive direction consistent with recovery (i.e. very severe to moderate, mild or none; severe to mild or none; moderate to none)
- change in individual symptom scores of two or more points indicative of symptom worsening or deterioration
- numerical and percent change from baseline on each of the four factor scores
- numerical and percent change from baseline in total symptom score and verbal descriptors of such change as worse, no significant change, modest improvement, moderate improvement, and marked improvement
- comparison of total and factor scores to demographically matched healthy active duty SMs (as soon as the norms become published and available)

Data about clinically meaningful change in symptoms with concussion care provided in the MHS to SMs is of interest to DoD senior leadership. It is recommended that data be aggregated across the MTFs by patient characteristics (service, demographics, time since injury, number of concussions, co-morbidities, etc.) and care setting (primary care, specialty care, TBI clinics, rehabilitation). Data will be summarized with the caveat that empirically derived standards for clinically significant change do not yet exist.

Aggregated data sets will be presented as system performance metrics suggestive of modest, moderate and marked improvement/treatment response in symptoms and post-concussive symptom clusters and return to a healthy state (not necessarily symptom free).

## 6. SERIAL ADMINISTRATION AND CONCUSSION HEALTH CARE UTILIZATION

There is a wide range in the number of visits among patients with the concussion diagnosis and variation between concussion care settings. An operational study of concussion health care utilization by OOA in collaboration with the Air Force Medical Support Agency (AFMSA) utilizing data in the Health Services Data Warehouse showed that the mean number of visits to a MTF in 2010 – 2012 for a concussion diagnosis (850.0; 850.11) was five (range = 1 – 189); 81% of this sample was seen for five or

fewer concussion related medical visits. Only 47% of those diagnosed with concussion return for follow-up care. For those SMs returning for following up care, 5,839 were seen for two to five visits, 1,826 were seen for six to 10 visits, 1,161 were seen for 11 to 20 visits, and 1,252 were seen for more than 20 visits. The time interval between visits is not known.

## 7. OFFICE OF OUTCOMES AND ASSESSMENT SERIAL MEASUREMENT RECOMMENDATIONS

To collect concussion health care outcome data most efficiently, patient reported outcome measures including the NSI will be completed in conjunction with concussion medical encounters. However, measure completion at each provider visit could become burdensome for SMs with lengthy courses of care and in settings such as rehabilitation which provide multidisciplinary care. In addition, the data derived from such frequent measure administration would be of dubious value to those providers. Therefore, the proposed recommendation is that the NSI be administered at the initial concussion diagnostic visit and all subsequent medical appointments for the initial five concussion related visits but not to exceed administration once every two weeks for all subsequent concussion related medical encounter.

The instructions with regard to the time interval for the NSI that appear in the Cicerone and Kalmar (1995) paper reference the patient to evaluate symptoms since the injury. However, other versions of the NSI use either a two week or one month time interval. The drawback of using the time frame of since injury for symptom reporting particularly in patients with persisting post-concussion symptoms is that the patient's attention is drawn to the injury as a source of symptoms, thus potentially creating attribution bias (Cicerone, 2014). Thus, the recommendation is that the initial NSI administered use the injury as the reference point provided the patient is diagnosed with concussion within 90 days of an injury event. It is recommended that follow-up administrations of the NSI use the prior medical appointment or the past two weeks as the time frame for symptom reporting.

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INFORMATION PAPER  
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APPENDIX A: Neurobehavioral Symptom Inventory (NSI); Initial Concussion  
 Diagnostic Visit

Symptom Report					
Please rate the following symptoms with regard to how much they have disturbed you SINCE YOUR INJURY.					
The purpose of this inventory is to track symptoms over time. Please do not attempt to score.					
<b>0 = None</b> – Rarely if ever present; not a problem at all					
<b>1 = Mild</b> – Occasionally present, but it does not disrupt my activities; I can usually continue what I’m doing; doesn’t really concern me.					
<b>2 = Moderate</b> – Often present, occasionally disrupts my activities; I can usually continue what I’m doing with some effort; I feel somewhat concerned.					
<b>3 = Severe</b> – Frequently present and disrupts activities; I can only do things that are fairly simple or take little effort; I feel I need help.					
<b>4 = Very Severe</b> – Almost always present and I have been unable to perform at work, school or home due to this.					
Symptom	0	1	2	3	4
Feeling dizzy	0	0	0	0	0
Loss of balance	0	0	0	0	0
Poor coordination, clumsy	0	0	0	0	0
Headaches	0	0	0	0	0
Nausea	0	0	0	0	0
Vision problems, blurring, trouble seeing	0	0	0	0	0
Sensitivity to light	0	0	0	0	0
Hearing difficulty	0	0	0	0	0
Sensitivity to noise	0	0	0	0	0
Numbness or tingling on parts of my body	0	0	0	0	0
Change in taste and/or smell	0	0	0	0	0
Loss of appetite or increased appetite	0	0	0	0	0
Poor concentration, can’t pay attention, easily distracted	0	0	0	0	0
Forgetfulness, can’t remember things	0	0	0	0	0
Difficulty making decisions	0	0	0	0	0
Slowed thinking, difficulty getting organized, can’t finish things	0	0	0	0	0
Fatigue, loss of energy, getting tired easily	0	0	0	0	0
Difficulty falling or staying asleep	0	0	0	0	0
Feeling anxious or tense	0	0	0	0	0
Feeling depressed or sad	0	0	0	0	0

Irritability, easily annoyed	0 0 0 0 0
Poor frustration tolerance, feeling easily overwhelmed by things	0 0 0 0 0

APPENDIX B: Neurobehavioral Symptom Inventory (NSI); Follow-up Concussion Visits

Symptom Report					
Please rate the following symptoms with regard to how much they have disturbed you SINCE YOUR LAST MEDICAL VISIT/IN THE PAST TWO WEEKS.					
The purpose of this inventory is to track symptoms over time. Please do not attempt to score.					
<b>0 = None</b> – Rarely if ever present; not a problem at all					
<b>1 = Mild</b> – Occasionally present, but it does not disrupt my activities; I can usually continue what I’m doing; doesn’t really concern me.					
<b>2 = Moderate</b> – Often present, occasionally disrupts my activities; I can usually continue what I’m doing with some effort; I feel somewhat concerned.					
<b>3 = Severe</b> – Frequently present and disrupts activities; I can only do things that are fairly simple or take little effort; I feel I need help.					
<b>4 = Very Severe</b> – Almost always present and I have been unable to perform at work, school or home due to this.					
<b>Symptom</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Feeling dizzy	0	0	0	0	0
Loss of balance	0	0	0	0	0
Poor coordination, clumsy	0	0	0	0	0
Headaches	0	0	0	0	0
Nausea	0	0	0	0	0
Vision problems, blurring, trouble seeing	0	0	0	0	0
Sensitivity to light	0	0	0	0	0
Hearing difficulty	0	0	0	0	0
Sensitivity to noise	0	0	0	0	0
Numbness or tingling on parts of my body	0	0	0	0	0
Change in taste and/or smell	0	0	0	0	0
Loss of appetite or increased appetite	0	0	0	0	0
Poor concentration, can’t pay attention, easily distracted	0	0	0	0	0
Forgetfulness, can’t remember things	0	0	0	0	0
Difficulty making decisions	0	0	0	0	0
Slowed thinking, difficulty getting organized, can’t finish things	0	0	0	0	0
Fatigue, loss of energy, getting tired easily	0	0	0	0	0
Difficulty falling or staying asleep	0	0	0	0	0
Feeling anxious or tense	0	0	0	0	0
Feeling depressed or sad	0	0	0	0	0

Irritability, easily annoyed	0	0	0	0	0
Poor frustration tolerance, feeling easily overwhelmed by things	0	0	0	0	0