1-1-2012

The use of Cognitive Profiles in Providing Supervisory Discharge Recommendations in a Traumatic Brain Injury Population

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INTRODUCTION

Traumatic brain injury (TBI), as defined by the National Institute of Neurological Disorders and Stroke (2011), is an acquired brain injury that occurs when a sudden trauma induces damage to the brain. TBI is associated with a head injury (HI), which is a nonspecific injury that may include external injuries (lacerations, contusions, abrasions, fractures) to the face, scalp, or calvarium (Bruns, 2003). Although falls, motor vehicle crashes, striking of the head events, and assaults are the most prominent causes of TBI, the mechanism of TBI is strongly associated with an individual's demographics in developed regions (Annegers, Grabow, Kurland, & Laws, 1980). Falls are especially common causes of TBI in children as well as the elderly while violence and moving vehicle accidents are the primary source of brain injury in males and ethnic minorities (Cooper, Tabaddor, Hauser, Shulman, Feiner, & Factor, 1983). Additionally, sports and recreational activities are emerging as a prominent cause of the injury in domestic populations, and war-zone blasts are becoming the leading cause of the injury in active duty military personnel (Thurman, Branche, & Sniezek, 1998; Okie, 2005).

Despite the general lack of recognition of this injury, TBI is a primary cause of disability, morbidity, and mortality in individuals under 45 years of age (Sosin, Sacks, & Smith, 1989). The incidence rate of this condition has been estimated at 1.4 million TBI cases each year, with 235,000 hospitalizations and 50,000 deaths (Murray & Lopez, 1996). Unfortunately, the incidence of this injury is not a clear-cut subject of research, as TBI research tends to lack standardization in terms of definitions, inclusion criteria, and diagnostic criteria. Oftentimes, the definition of a TBI case and inclusion criteria vary widely among researchers and institutions. Additionally, studies are sometimes unable to include individuals who acquire injuries abroad, or those who are treated for traumatic brain injuries in hospital outpatient settings or physicians' offices (Langlois, Rutland-Brown, & Thomas, 2004). Another factor that deters TBI incidence tracking elucidated through a review by Bruns *et al.* (2003) is the current trend of deinstitutionalization of TBI management. Such deinstitutionalization is a result of better neuroimaging techniques as well as more rigorous hospital admission policies (Bruns *et* *al.*, 2003). An even more troublesome fact is that a large proportion of mild traumatic brain injuries go undiagnosed and untreated, and these cases are not included in studies examining the incidence of this injury (Finkelstein, Corso, & Miller, 2006). Such complications tend to underestimate mild TBI and overestimate the proportion of severe TBI (Bruns, 2003).

Given the high prevalence of this ailment, it is crucial to have an understanding of the impact of such a condition on quality of life before treatment can be adequately addressed. TBI can result in long-lasting physical, cognitive, behavioral, and emotional consequences, as shown by the two percent of the United States population who are currently living with long-term disabilities associated with TBI (Langlois *et al.*, 2006). Neuropsychological as well as behavioral deficits, which determine successful social and occupational reintegration, tend to appear after the acute phase of TBI. The delayed appearance of these neuropsychological and behavioral deficits oftentimes deters a targeted analysis of behavioral deficits for up to three months post-injury as disturbances in orientation and concentration leave a patient unequipped to complete a neurobehavioral examination. In some instances, the behavioral deficits can persist or increase in severity even after six and twelve months post-injury, with the highest degree of disability in attention, concept building, increased excitability, and planning abilities. The emergence of such deficits is thought to be a result of increasing interaction with family members and social environment, as well as an increase in mobility and decrease in sensomotoric deficits. The severe impact of TBI emphasizes the need for early assessment of sensomotoric, neuropsychological, and behavioral deficits to ensure that appropriate cognitive rehabilitation can be developed and adapted (Lippert-Gruner, Kuchta, Hellmich, & Klug, 2006).

The early neuropsychological assessment of individuals with TBI can minimize mortality and morbidity as well as enhance quality of life by highlighting appropriate medical care in acute and post-acute TBI settings (Malec, Mandrekar, Brown, & Moessner, 2009). Standardized methods for assessing TBI must not only provide a description of cognitive abilities, but also yield information about treatment and disposition planning (Doninger, Ehde, Bode, Knight, Bombardier, & Heinemann, 2006). Although exhaustive neuropsychological batteries furnish an extensive cognitive profile, they are impractical for routine administration and are particularly vulnerable to patient fatigue (Doninger, Bode, Heinemann, & Ambrose, 2000; Doninger *et al.*, 2006). On the other hand, conventional screening examinations of cognitive functioning, such as the Mini-Mental State Examination (MMSE), are brief and clarified with ease but they often produce high false negative and false positive rates that reduce the validity of such tests due to low specificity. Also, the brevity of such screening examinations limits information yields as these tests are commonly unequipped to isolate specific cognitive impairments, such as aphasia and apraxia (Doninger *et al.*, 2000).

Although both full neuropsychological batteries and screening examinations hold advantages and disadvantages, current healthcare trends emphasizing shorter patient stays are increasing the popularity of screening examinations. (Doninger *et al.*, 2000).

The Neurobehavioral Cognitive Screening Examination (NCSE), or Cognistat, is a brief screening instrument designed to quantify a variety of cognitive abilities in a testing period of approximately twenty minutes. Rather than providing a summation score like the majority of other screening examinations, the Cognistat independently assesses several cognitive functions, including level of consciousness, orientation, language, constructional praxis, memory, calculations, and reasoning. Performance in each subsection can be rated on a scale of average, mildly impaired, moderately impaired, and severely impaired to subsequently produce a concise, differentiated representation of cognitive abilities, or a cognitive profile. The feature that truly differentiates the Cognistat from its family of screening examinations is the screen and metric implementation of the examination, which provides examiners with a brief examination of normally functioning areas and an intensive examination of potential cognitive shortcomings, thus in essence combining the assets of full neuropsychological batteries and neuropsychological screening examinations (Doninger *et al.*, 2000).

The Cognistat has been found clinically useful in a variety of populations and oftentimes more so than other neuropsychological screening examinations. The use of the Cognistat has been validated in neurological patients (Cammermeyer & Prendergast, 1997), neurosurgical patients with documented brain lesions (Cammermeyer & Prendergast, 1997), stroke patients (Osmon, Smet, Winegarden, & Gandhavadi, 1992), geriatric individuals (Fields, Fulop, Sachs, Strain, & Fillit, 1992), as well as individuals with psychiatric disorders (Logue, Tupler, D'Amico, & Schmitt, 1993). In fact, the Cognistat has been shown to be significantly more sensitive to the effects of neurological impairment and normal aging than the Cognitive Capacity Screening Examination and Mini-Mental Status Examination (Doninger *et al.*, 2006). Among brain lesion populations, the classification accuracy of cognitive dysfunction by the Cognistat has been found to be 93 percent, compared to the 67 percent classification accuracy by the MMSE, and the 47 percent classification accuracy by the Cognitive Capacity Screening Examination (Doninger *et al.*, 2000). In a brain injury population, the Cognistat was proficient in identifying 86 percent of cognitive deficits while the MMSE was proficient in identifying only 53 percent of such deficits. Additionally, the Cognistat has been deemed sensitive to the unilateral effects of stroke and subtle cognitive changes resulting from postoperative complications. The superior efficiency and sensitivity of the Cognistat can be attributed to the separate domain scoring provided by the examination, rather than the global score provided by many other screening tests (Doninger *et al.*, 2000).

The Cognistat has been shown to be a particularly useful tool in the cognitive evaluation of individuals with TBI. Studies have shown twelve significant associations between the Cognistat and standard neuropsychological measures from full batteries of corresponding cognitive constructs, indicating the validity of the Cognistat in evaluating TBI populations (Doninger *et al.*, 2000). Despite its overall efficacy, the Cognistat does display some shortcomings in the examination of high functioning TBI populations, as shown by Doninger *et al.* (2000). The Cognistat was unable to produce differentiated profiles of cognitive abilities in a sample of high functioning adults with TBI. These results yielded poor separation indices, with the scores experiencing a "ceiling effect," in which a large portion of the sample scored disproportionately high on the exam. Conversely, the Cognistat has been found to have adequate separation indices in low functioning TBI populations, perhaps indicating that the examination is better adapted for samples with highly impaired cognitive functioning (Doninger *et al.*, 2006). The variation in the efficacy of the Cognistat in determining cognitive profiles across a wide range of TBI severity elucidates the need to further investigate the use of this neuropsychological screening examination in TBI populations.

A number of measures have been utilized to provide discharge recommendations for populations with TBI. In the transition from acute to post-acute settings, dubbed the "next level of care" decision, it is a common practice for rehabilitation specialists to be consulted to determine a patient's discharge plan (Malec *et al.*, 2009, p. 22). These specialists are the final factor in deciding whether an individual with TBI will be discharged to their home, temporarily transferred to a rehabilitation facility, or moved to a long-term nursing home. The decisions about the "next level of care" are based on inputs from patients, family members, and physicians so that the optimal subsequent placement of a patient can be determined. For example, a spouse's or family's ability to provide care, the age of the patient, and the presence of multiple disabilities have been found to influence "next level of care" decisions. (Malec *et al.*, 2009). Additionally, the Glasgow Coma Scale score has been strongly associated with acute morbidity and mortality and thus can be utilized in discharge assessments. Cognitive status at time of discharge has also been previously utilized to make "next level of care" decisions as the least impaired individuals have been sent home, moderately impaired individuals have been discharged to rehabilitation centers, and the most impaired patients have been discharged to nursing homes. On the other hand, gender, age, length of stay, and physical functioning at the time of discharge have not been shown to be associated with functional outcome, and thus are not useful in discharge decisions. A variety of factors have been assessed to formulate discharge recommendations, but the implementation of a standardized metric to support clinical decisions would increase consistency in such decision making (Baalen, Odding, & Stam, 2008).

Given the validity of the Cognistat in assessing TBI populations, this neuropsychological screening test can be applied to "next level of care" decisions in acute inpatient TBI populations. Despite the successful diagnostic validity of the Cognistat, it is not commonly used as a standardized neuropsychological examination to determine supervisory discharge recommendations in individuals with TBI. As Malec *et al.* (2009) and Baalen *et al.* (2008) suggested, more research into the use of particular patient variables, such as results from neuropsychological tests, could be useful in the standardization of discharge procedures of patients with TBI.

This study retrospectively examines the relationship between Cognistat scores and time-oriented supervisory discharge recommendations (24 hour supervision, intermittent supervision, or no supervision) in an acute TBI population of 125 inpatients. The expectations are that the combined reasoning and judgment subtest as well as the memory subtest are related to more restrictive supervisory recommendations than the remaining subtests of the Cognistat, including level of consciousness, orientation, attention, language, constructional ability, and calculations. More specifically, it is anticipated that impaired scores on the combined reasoning and judgment subtest and memory subtest will correlate strongly with discharge recommendations of 24 hour supervision, rather than intermittent supervision or no supervision. Impaired scores on the subtests of level of consciousness, orientation, attention, language, constructional ability, and calculations are not expected to significantly correlate with any specific discharge recommendations. The significance of the memory subtest was justified through findings of significant memory impairment in individuals with TBI (Doninger *et al.*, 2000), and the significant of the judgment subtest was justified though the finding of appearance of behavioral deficits that influence judgment in individuals with TBI (Lippert-Gruner *et al.*, 2006). Such an examination will provide insight into which variables of a patient's cognitive profile are most influential when providing time-oriented discharge determinations in inpatient traumatic brain injury populations.

METHODS

This study was a retrospective record review of Hartford Hospital inpatients with serial assessments for acute TBI conducted by neuropsychologists of the Institute of Living between January 2009 and December 2010.

Inclusion and Exclusion Criteria

Inpatients with acute traumatic brain injuries were selected for the study based on the following criteria: age over eighteen years, alert and oriented demeanor, adequate medical stability to participate in testing, and completion of the similarities and judgment subtests on the Cognistat. Individuals who were found in a delirium upon testing, were not able to communicate verbally, or had an auditory impairment were excluded.

Assessment Measures

Demographics

Demographic data collected through the record review included gender, age upon testing, marital status, race, ethnicity, level of education, and vocational status.

Neurocognitive Measures

Neurocognitive measures were obtained from the results of the Neurobehavioral Cognitive Status Examination, or Cognistat, a brief screening instrument (20 to 45 minute administration period) used to quantify a variety of cognitive functions, including level of consciousness, orientation, language, constructional praxis, memory, calculations, reasoning (similarities subtest), and judgment. The Cognistat was administered by the neuropsychologists of the Neuropsychology unit at the Institute of Living in Hartford, CT. Performance in each subsection is rated on a scale of average, mildly impaired, moderately impaired, and severely impaired. The Cognistat has a screen and metric implementation. A moderately challenging screen item that demands an unimpaired level of skill in a certain aspect of cognitive functioning is given for the majority of the subtests, including language, constructional praxis, calculations, reasoning, and judgment. If the screen item is passed, a maximum score is given on that subtest and no further testing in that subtest is completed; however, if the screen item is failed, a metric composed of a series of test items is administered and scored. Scores across a range of cognitive functions can subsequently be compiled to generate a cognitive profile.

Discharge Recommendations

Time-oriented supervisory recommendations provided by the examining neuropsychologist were based on Cognistat results and other collected clinical data that was not examined in this study. The supervisory recommendations were either no supervision necessary, intermittent supervision, or 24-hour supervision. Additionally, the identity of the staff neuropsychologist who provided the supervisory recommendation was noted for each subject.

Processing Data and Analysis

As the purpose of this study was to determine how the cognitive profiles differ with respect to discharge supervisory recommendations, data analysis consisted of examining which patient variables (age at testing, years of education, and scores on Cognistat subtests) associated best with the most restrictive supervisory recommendations. A forward step-wise logistic regression was completed to determine which patient variables were the strongest predictors of a recommendation of intermittent supervision or 24-hour supervision. The no supervision recommendation category was excluded from the analysis because this recommendation was found in an insignificant proportion within the sample. In this analysis, the first step was to establish that a relationship exists between the patient variables. Once a relationship was established, the patient variables that didn't associate with supervisory recommendations were eliminated. After the reduction of the set of predictors, the equation produced by the logistic regression could be used to predict supervisory recommendations for future patients on a probabilistic basis.

Patient Safety and Ethical Considerations

The extraction of data from the de-identified database of archival data did not compromise the safety of patients involved in the research. All de-identified data were maintained on a password protected computer at the Institute of Living to guarantee patient confidentiality. Informed consent was deemed unnecessary by the Hartford Hospital Institutional Review Board.

RESULTS

Sample Population

This retrospective study examined seventy-six Hartford Hospital inpatients with acute traumatic brain injury that had been assessed by the Neuropsychology Unit at the Institute of Living between January 2009 and December 2010. Of these seventy-six patients, sixteen patients were excluded from the study as they were given the "no supervision required" recommendation (table 1), which was deemed to be of little interest when examining Cognistat scores and supervisory recommendations.

Thus, the sample size of this study comprised of sixty patients who were given the intermittent or 24 hour supervisory recommendation (table 2). There were no significant differences within the demographic measures (all $p>0.05$).

Table 1. Supervisory Discharge Recommendations

Supervisory Recommendation	Frequency	Percentage
No Supervision	16	21%
Intermittent Supervision	26	34%
24 Hour Supervision	34	45%

Table 2. Demographics of Participants Sorted By Supervisory Recommendation

Supervisory Recommendation		Intermittent	24 Hour
Age	Mean	44 ± 16 years	40 ± 17 years
Years of Education	Mean	14 ± 2.5 years	13 ± 2.8 years
Gender	Male	21	27
	Female	5	7
Marital Status	Single	13	19
	Married	8	9
	Divorced	4	5
	Widowed	1	1
Race	White	23	25
	Black	0	2
Ethnicity	Non-Hispanic	23	27
	Hispanic	1	4
	Unreported	2	3

Association between Cognistat Scores and Supervisory Discharge Recommendations

For descriptive purposes, the Cognistat scores of the sixty patients were summarized in terms of minimum score, maximum score, and mean score for each subtest (table 3). It was found that scores on the attention, comprehension, repetition, and construction subtests were skewed and kurtotic, indicating a ceiling effect on these subtests. As a result of the consistently high scores on these subtests, they were excluded from the binary logistic regression as they were determined unfit to accurately predict supervisory recommendations. The orientation and naming subtests were also excluded from the binary logistic regression, as they were deemed clinically irrelevant in determining supervisory discharge recommendations.

Table 3. Scores on Cognistar

Subtest	Min. Score	Max. Score	Mean Score ± St. Dev.
Orientation	5	12	10 ± 2.2
Attention *	2	8	7.3 ± 1.4
Comprehension *	0	6	5.46 ± 1.3
Repetition *	0	12	11 ± 2.4
Naming	4	8	7.4 ± 1.0
Construction *	0	5	4.2 ± 1.8
Memory	0	12	6.7 ± 3.2
Calculations	0	4	2.9 ± 1.4
Similarities	0	8	4.9 ± 1.9
Judgment	0	6	4.1 ± 1.7

* Skewed and kurtotic data

Correlations of Variables Used in Binary Logistic Regression

A Pearson correlation indicated that the scores of all four Cognistat subtests examined (memory, calculations, similarities, and judgment) correlated with the supervisory recommendation (all $p<0.05$). Age at testing and years of education were not found to correlate with neither the intermittent nor 24 hour supervisory recommendation (table 4). Upon further examination, all four Cognistat subtests correlated with the intermittent and 24 hour supervisory recommendation while age at testing and years of education did not correlate with neither the intermittent nor 24 hour supervisory recommendation (table 5).

Table 4. Pearson Correlation of Variables in Binary Logistic Regression

	Supervision	Age at testing	Years of education	Cognistat Memory	Cognistat Calculation	Cognistat Similarities	Cognistat Judgment
Age at testing	-.100	-	-	-	-	-	-
Years of education	0.78	.0952	-	-	-	-	-
Cognistat Memory	-.516**	.001	.219	-	-	-	-
Cognistat Calculations	-.324*	-.101	.073	.393**	-	-	-
Cognistat Similarities	-.454**	-.028	.119	.469**	.465**	-	-
Cognistat Judgment	-.356**	.178	.116	.476**	.486**	.534**	-

**P<0.01, *P<0.05

Table 5. Pearson Correlations of Variables Vs. Supervisory Recommendations

	Intermittent Supervision	24 Hour Supervision
Age at testing	.100	-.100
Years of education	.246	-.246
Cognistat Memory	.516**	-.516**
Cognistat Calculations	.324*	-.324*
Cognistat Similarities	.454**	-.454**
Cognistat Judgment	.356**	-.356**

**P<0.01, *P<0.05

Logistic Regression Analysis

A stepwise forward logistic regression analysis was completed to determine the predictive power of age at testing, years of education, and select Cognistat subtests (calculations, memory, similarities, and judgment) on the supervisory discharge recommendations (entry=0.05, removal=0.1). In this analysis, a three-step equation emerged (table 6) in which the total R^2 value (table 7) and classification accuracy (table 8) improved at each step.

Table 6. Binary Logistic Regression Variables in Equation

		B	S.E	Wald	df	Sig.	Exp(B)
Step 0	Constant	.278	.265	1.096	1	.295	1.320
Step 1[a]	Cognistat Memory	-.509	.140	13.166	1	.000	.601
	Constant	3.874	1.071	13.095	1	.000	48.152
Step 2[b]	Years of education	.034	.031	1.244	1	.265	1.035
	Cognistat Memory	-.590	.159	13.685	1	.000	.554
	Constant	3.912	1.188	10.844	1	.001	49.995
Step 3[c]	Years of education	.037	.036	1.061	1	.303	1.038
	Cognistat Similarities	-.565	.279	4.107	1	.043	.568
	Cognistat Memory	-.507	.167	9.242	1	.002	.603
	Constant	6.275	1.912	10.768	1	.001	531.099

Table 7. Binary Logistic Regression Model Summary

Step	Cox & Snell R Square	Nagelkerke R Square
1	.308	.413
2	.349	.468
3	.409	.549

Table 8. Binary Logistic Regression Classification Table

Step	Overall Percentage Correct
Step 0	56.9
Step 1	75.9
Step 2	77.6
Step 3	82.8

DISCUSSION

Out of the patient variables considered (age at testing, years of education, Cognistat calculations subtest, Cognistat memory subtest, Cognistat similarities subtest, and Cognistat judgment subtest), correlations indicated that only the Cognistat subtests correlated with both the intermittent and 24 hour supervisory recommendations. On the other hand, the binary logistic regression revealed years of education, the Cognistat similarities subtest and the Cognistat memory subtest were the best predictors of supervisory discharge recommendations. These results suggest the patient variables that best predict supervisory discharge recommendations and thus establish a model for future supervisory discharge recommendations.

Age at Testing

Age at testing did not correlate with supervisory discharge recommendations and did not enter into the logistic regression as an important predictive factor. Previous studies examining the influence of age on TBI outcomes have reported mixed findings. A study by Malec *et al.* (2009) found a significant difference between discharge recommendations (nursing facility versus inpatient rehabilitation versus home) for individuals under the age of 65 and over the age of 65. On the other hand, in a study by Baalen *et al.* (2008), age was not found to be independently associated with discharge destination, but this study excluded patients over the age of 66 years, thus perhaps explaining the lack of age effect. The lack of age effect on supervisory discharge recommendations in this population suggests that although age at testing may be important for the determination of discharge location in an age-balanced population, it does not play an important role in determining supervisory discharge recommendations.

Years of Education

Although years of education was not found to independently correlated with supervisory discharge recommendations, the logistic regression indicated that this variable has predictive power of supervisory discharge recommendations when the scores of the Cognistat similarities and memory subtests are considered. It was discovered that patients with higher levels of education were more likely to be recommended 24 hour supervision. This can be explained by the expectation of higher scores on the Cognistat subtests in individuals with higher levels of education. If this expectation was not met, concerns of severe impairment in these patients were evoked, and thus more restrictive supervisory recommendations were given.

The examination of the influence of years of education on discharge recommendations in TBI populations has been very limited. One study that did examine this variable had a patient population in which there were many more patients with a low education (78%) than a high education (14%). This study deemed years of education to be of no significance in determining discharge recommendations, but this finding could be attributed to the skewed population (Baalen *et al.,* 2008). The current study appears to be the first in implicating the significance of years of education when determining supervisory discharge recommendations and such a finding is validated by the even distribution of educational level among the study sample.

Cognistat Subtests

Although all four Cognistat subtests considered (calculations, memory, similarities, and judgment) correlated with supervisory discharge recommendations, the logistic regression revealed that the memory and similarities subtests were the best predictors of more restrictive recommendations. More specifically, impaired scores on the memory and similarities subtests were better predictors of the 24 hour supervisory recommendation than impaired scores on the calculations and judgment subtests.

The overall validity of the Cognistat in TBI populations has been shown through significant associations between the Cognistat and standard neuropsychological measures from full batteries of corresponding cognitive constructs (Doninger *et al.*, 2000). The Cognistat has also been shown to have high discriminative validity when comparing the performance of individuals with TBI and demographically matched controls (Gupta & Kumar, 2009).

The specific significance of the memory and similarities subtests is supported by previous findings on the use of the Cognistat in a TBI population that reported memory and verbal reasoning (the similarities subtest) to be the most difficult domains. This finding is consistent with clinical accounts of persistent neurological deficits, particularly in memory and reasoning skills, after TBI (Doninger *et al.*, 2000).

Limitations

Limitations of this study include the inability to include all of the Cognistat subtests in the step-wise logistic regression as a result of skewed and kurtotic data on the attention, comprehension, repetition, and construction subtests. If adjusted to eliminate the ceiling effect, these subtests could be found to hold clinical significance in providing supervisory discharge recommendations.

Conclusion

This study successfully establishes a model for providing supervisory discharge recommendations for inpatients with traumatic brain injury. The predictive power of years of education, the Cognistat memory subtest, as well as the Cognistat similarities subtest on supervisory discharge recommendations indicates that these variables are given much consideration when providing supervisory discharge recommendations for inpatients with traumatic brain injury. Such findings are useful in establishing a standardized model for providing future discharge recommendations for patients with traumatic brain injury.

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