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Depression as a predictor of long-term employment outcomes among individuals with moderate-to-severe traumatic brain injury

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Abstract

Objective: To examine the predictive ability of depression when considering long-term employment outcomes for individuals with moderate-to-severe TBI, after controlling for key pre-injury and injury-related variables.

Design: Secondary data analysis.

Setting: Community follow-up after discharge from an inpatient rehabilitation center.

Participants: Individuals between 18 and 60 years-old with moderate-to-severe TBI enrolled in the Traumatic Brain Injury Model Systems (TBIMS) database.

Interventions: Not applicable.

Main Outcome Measures: Employment status.

Results: The prevalence of employment at 2 and 5 years post-injury was 40.3% and 44.5%, respectively. Individuals identified at depressed at 1 year were less likely to be employed at 2 years post-injury (OR=1.77; 95% CI: 1.38, 2.27; p<.0001). Similar relations between current depression and future employment were observed from 1- and 2-year depression status predicting 5-year employment (1-year: OR=1.88; 95%CI: 1.48, 2.40; p<.0001: 2-year: OR=1.72, 95%CI: 1.36, 2.17; p<.0001).

Conclusions: After controlling for baseline predictors variables, the experience of post-injury depression—a modifiable condition—contributes predictive ability to future employment outcomes. Incorporating assessments/interventions for depression into post-acute rehabilitation programs could promote favorable employment outcomes after TBI.

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Keywords

Traumatic brain injury; employment; depression

INTRODUCTION

Traumatic brain injury (TBI) is a complex condition with a high degree of variability in recovery patterns and a range of functional outcomes. [1–3] Impairments resulting from moderate-to-severe TBI can affect physical, cognitive, emotional, and social functioning. [4–11] Such impairments can contribute to disability and inhibit an important benchmark of recovery for many individuals with TBI—return to work. Beyond lost productivity, reduced personal income, and loss of employer-sponsored health insurance, unemployment or underemployment is associated with negative global outcomes such as reduced quality of life. [12,13]

Rates of employment after TBI vary across study samples and timeframes. Cuthbert et al. found the prevalence of unemployment at two years post-injury to be 60.4% and part-time employment to be 35.0%. [14] Comparing individuals with TBI to individuals with traumatic orthopedic injuries, Dahm and Ponsford found that individuals with TBI were less likely to remain in the workforce at ten years post-injury, with rates of unemployment ranging from 46% at one-year post-injury to 36% at ten-years. [15] DiSanto et al. found that approximately 27% of individuals with moderate-to-severe TBI had stable employment over a five-year period, 53% were consistently unemployed, 9% had unstable employment, and 10% experienced a significant delay in their ultimate return to work. [16]

Because attainment of employment is such a critical ecologic outcome, researchers have devoted much attention toward identifying its predictors. Non-modifiable predictive factors typically include pre-injury sociodemographic variables, injury-related factors, and global economic trends. Lack of employment after TBI is associated with older age, being non-white, lower educational attainment, and employment status prior to injury. Those who are unemployed or employed in lower-skill occupations at the time of injury are more likely to be unemployed after injury. [15–17] Among injury or treatment-related variables, unemployment is associated with injury severity indicators such as the duration of posttraumatic amnesia, a longer hospital length of stay, and discharge from the hospital to a nursing facility. [17,18] Post-injury factors that may be modifiable and thus more amenable to intervention have more complex interactions with employment outcomes. However, past research in this area has concentrated on cross-sectional analyses, which raises doubt regarding the directionality of associations between these factors and employment outcomes. Using cross-sectional design, researchers have found post-injury factors such as pain, decreased mobility, persistent cognitive impairment, substance misuse, and other psychiatric symptoms to be associated with higher risk of unemployment. [18,19]

Psychiatric conditions are especially important modifiable post-injury predictors of unemployment given their prevalence after TBI. Already common in the general population, individuals with TBI have even higher rates of psychiatric disorders, including depression. [9,10] Dikmen, et al. observed rates of depression that ranged from 31% at 1-month post injury to 17% at 3-to-5 years post injury. [20] Bombardier et al. observed a rate of major depression among individuals with TBI that was seven times higher than the general population (i.e., 53.1% vs. 6.7%). [21] In their examination of employment stability over the first five years following moderate-to-severe TBI, DiSanto et al. noted that depression predicted unemployment and overall employment stability; they also found that rates of depression increased among individuals with TBI who experienced unstable employment. [16]

Thus, there appears to be an association between post-injury depression and employment after TBI, but it remains difficult to draw inferences about the causal relation between these two constructs, and it is unclear how much explanatory power post-injury depression contributes beyond other known predictive variables. The aim of the current study is to examine the predictive ability of depression when considering future long-term employment outcomes for individuals with moderate-to-severe TBI, after controlling for key pre-injury and injury-related variables identified using classification tree modeling in a previous study. [22]

METHOD

Participants

All participants in these analyses consented to be enrolled in the Traumatic Brain Injury Model Systems (TBIMS) national database. [23] All TBIMS enrollment and data collection centers were granted institutional review board approval and adhered to Good Clinical Practice. Inclusion criteria include (1) being 16 years or older at the time of injury, (2) admission to a TBIMS acute care hospital within 72 hours of injury, (3) receiving care through a TBIMS Center, and (4) sustaining a TBI with any of the following: Glasgow Coma Scale score at emergency admission of <13 (not due to intoxication, intubation, or sedation); loss of consciousness, not due to sedation or intoxication, for >30 minutes; post-traumatic amnesia (PTA) > 24 hours; or injury related CT findings. [23] Exclusion criteria matched those used to build the classification tree models developed as part of a prognostic methodology to predict employment following TBI. [22] These included restricting the age of participants to be between 18 and 60 years and excluding those injured prior to 1997 due to differing variable definitions before and after this date. Participants who had a penetrating TBI, missing employment or PTA duration information were also excluded. Furthermore, participants with missing PHQ-9 (depression) information were excluded from these analyses.

Outcomes

The outcome of interest was competitive employment at 2 or 5 years post-injury. Competitive employment was defined as participant report of full or part-time job employment of at least minimum wage and excluded supported employment.

Predictors

The predictor of primary interest was depression status, measured by the Patient Health Questionnaire-9 (PHQ-9). [24, 25] The PHQ-9 is a nine-item depression screening measure based on DSM diagnostic criteria for a depressive episode. Respondents rate how often in the last two weeks they have been bothered by depressive symptoms. Responses include "not at all – 0," "several days – 1," "more than half the days – 2", and "nearly every day – 3." The PHQ-9 has demonstrated strong sensitivity (0.93) and specificity (0.89) with a positive predictive value of 0.63 and negative predictive value of 0.99 among individual with TBI. [26] Consistent with criteria proposed by Fann et al., participants who endorsed (1) at least five items as "several days" or more plus (2) the presence of at least one cardinal symptoms of depression (i.e., anhedonia or depressed mood) were classified as "depressed." [26]

Participants' demographic, pre-injury, and injury characteristics were incorporated using the results of a classification tree analysis previously reported. [22] Classification tree methodology allows the building of intuitive predictive models based on branching logic. They provide predictive probabilities of class membership based on node membership. Variables appearing higher in the tree are inherently more related to the outcome than ones splitting lower in the tree. The terminal nodes of this analysis were used to classify participants into homogenous subgroups that each had similar employment rates. These subgroups were determined by factors such as duration of post-traumatic amnesia, age, pre-injury education, and both pre-injury employment status and type. Full details on the characteristics of each group can be found in Tables 2 and 3. The strategy of using the results of a classification tree analysis to classify participants into homogenous subgroups has been used previously to identify modifiable characteristics that were related to employment in a sample of youth with disabilities. [27]

Among our data the prevalence of depression was too low in some subgroups to perform generalizable analyses. In these instances, subgroups/terminal nodes were combined to form new subgroups with sample sizes large enough to perform meaningful statistical analyses. This resulted in 11 and 8 subgroups for 2- and 5-year assessment of post-injury depression on employment, respectively. The same sample used to develop the classification tree models was used in these analyses except for participants with missing depression information.

Data Analyses

Frequencies and percentages or medians and interquartile ranges (IQRs) were calculated for each study variable. The frequency and percentage of participants who were employed at 2 and 5 years and who were clinically depressed at 1 and 2 years post-injury were calculated within each risk group.

Three sets of analyses were conducted, each examining 3 models: Analysis 1 used 1-year depression to predict 2-year employment; Analysis 2 used 1-year depression to predict 5-year employment; and Analysis 3 used 2-year depression to predict 5-year employment. Within each Analysis, three separate logistic regression models were used to assess the predictability of depression status on employment status at 2 or 5 years post-injury. The first model included each participant's employment status at 1 year post-injury and their subgroup from prior decision tree analyses described above. Subsequent analyses added the

1- or 2-year depression status (model 2) and the interaction between the depression status and subgroup (model 3).

For each model, the area under the receiver operating curve (AUC) was calculated to assess the model fit. AUC values range from 0.5-1 where 0.5 is considered random predictability, 0.7-0.8 indicates an acceptable model, 0.8-0.9 is exceptional model fit, and 0.9-1 is outstanding. [28] If adding a predictor (depression in model 2 and the interaction in model 3) yielded a significant effect, the AUCs from each model were compared using Delong's Test, a non-parametric method, to determine if the addition of the predictor significantly increased the fit. [29] If the predictor was not significant then comparison was not performed, as suggested by Demler et al. [30]. All inference was performed at the 0.05 level.

RESULTS

Descriptive statistics for participants included in any of the analyses are provided in Table 1. The sample was predominately male (75.2%) and had a median age of 32 years. Approximately 75% of the sample was competitively employed pre-injury, with 18.3%, 40.7%, and 16.0% having employment in professional, skilled and manual labor jobs respectively. The overall employment rate was 36.6% at 1 year post-injury, 40.3% at 2 years, and 44.5% at 5 years.

Tables 2 and 3 describe the employment rate of participants in each of the terminal nodes for year-2 and year-5 and depression rate at years 1 and 2. Generally, subgroups with higher rates of being depressed at 1 or 2 years post-injury corresponded to lower levels being employed at subsequent follow-up periods. For instance, participants who spent less than 3 weeks in PTA, were not employed pre-injury, and were older than age 33 (node 15), had the highest depression rate (61%) at 1 year post-injury and had only a 10% employment rate at 2 years post-injury (Table 2). The lowest depression rate at 1 year post-injury, at 33%, occurred in participants who were in PTA for 4 weeks and had more than a high school education (node 6). This group had a 2 year post-injury employment rate of 47%.

After adjusting for employment status at 1 year post-injury and subgroup based on demographic and injury factors to predict 2-year post-injury employment, individuals who were depressed at 1 year were less likely to be employed at 2 years (OR=1.77; 95% CI: 1.38, 2.27; $P<.0001$). Using the same adjustments, significant relations between current depression and future employment were also observed for 1- and 2-year depression status predicting 5-year employment (1-year: OR=1.88; 95%CI: 1.48, 2.40; $p<.0001$: 2-year: OR=1.72, 95%CI: 1.36, 2.17; $p<.0001$). Information on the relations between current depression and future employment status across when adjusted for current employment across all the prognostic group nodes can be found in the online supplement.

Table 4 shows the AUC values for all the models constructed, with all demonstrating very good model fit. In each prediction time-frame analysis, current depression was a significant predictor when added to the initial model that used baseline predictors and then adjusted for current employment (Table 5). Thus, current depression status significantly enhanced predictability of future employment beyond the baseline prognostic node information and current employment status. In all three analyses, the interaction between terminal node and current depression was not a significant predictor of future employment. Therefore, the relation between depression and future employment did not differ across prognostic subgroups.

DISCUSSION

Summary

This secondary data analysis examined long-term employment outcomes in the TBIMS cohort of patients with moderate and severe TBI. Across the entire sample, the employment rate at 2 and 5 years post-injury was 40.3% and 44.5%, respectively, which is consistent with the long-term unemployment rates observed in the TBI recovery literature (i.e., in previous analyses of the TBIMS national database and in other samples). [14–19]. The first aim of the current study was to examine whether depression during recovery from moderate-to-severe TBI predicted future long-term employment status after (a) controlling for fixed pre-injury and injury-related variables known to be associated with return to work and while (b) controlling for current employment status. Controlling for the fixed variables was done using the results of a prior classification tree analysis to simultaneously group the patients by initial prognosis levels.

We found that the addition of current depression added significantly to predicting future employment status both across the entire sample and within most prognostic groupings. Although the incremental gain in AUC across the models was small, the baseline models were already robust. There is inherent variability in employment outcomes from unmeasured clinical (e.g. comorbidity), person (e.g. self-motivation), and environmental (e.g. financial) factors, such that if any modifiable variable can be shown to have predictive ability, it may be clinically important regardless of degree. Nevertheless, to aid clinical interpretation of our findings, we also calculated and reported overall adjusted odds ratios for each model. These showed that non-depressed individuals are nearly twice as likely to be employed in future years compared to depressed individuals. The predictive ability of depression was relatively consistent over time. More specifically, an individual with depression had greater likelihood of being unemployed at an odds ratio that ranged tightly from 1.72 to 1.88 across the 3 longitudinal time frames examined (i.e., Year-1 to Year-2; Year-1 to Year-5; and Year-2 to Year-5).

The second aim was to determine whether the association between post-injury depression and future employment status differed between patient groups with different initial prognoses. However, the degree of the effect of depression on future employment did not differ across prognostic groups. Thus, we did not identify any groups more vulnerable than others such that the effect of post-injury depression on future long-term employment outcomes is irrespective of initial prognosis based on demographic, pre-injury, and injury-related variables.

Implications

Identifying a potentially *modifiable* predictor of long-term employment outcomes among individuals with TBI is a key finding of this study. Distinct from nonmodifiable demographic, pre-injury and injury-related factors, the experience of depression represents a target for assessment and intervention. Screening for depression can be readily achieved through measures validated for use among individuals with TBI, such as the PHQ-9. [26] In their comprehensive review of treatments for depression following TBI, Fann, Hart, and Schomer describe evidence supporting the use of pharmacological interventions such as antidepressants, particularly selective serotonin uptake inhibitors (SSRIs). [31] Although studies of psychotherapeutic interventions for depression following TBI enjoy less robust empirical support, there is promise associated with cognitive-behavioral interventions, behavioral activation, mindfulness-based interventions, and problem-solving focused strategies. [32–35] These interventions are effective in addressing depression in the general population and can be modified to accommodate the unique needs of individuals with TBI. [36] The provision of such counseling or psychotherapeutic interventions is a key element of empirically supported models of vocational rehabilitation, such as supported employment. [37]

The methodology of the current study advances our understanding of the association between emotional functioning and return to work after TBI. First, the application of the classification tree analysis allows for an examination of the incremental explanatory power of a modifiable risk factor (i.e., depression) beyond the prognostic utility of baseline variables known to be associated with return to work after TBI. Second, the longitudinal nature of the study allows for stronger causal inference than the cross-sectional research that typifies studies of functional outcomes associated with TBI.

Limitations

Although the TBIMS national database represents the largest collection of pre-injury, injury-related, and longitudinal outcomes among patients with moderate-to-severe TBI, there are limitations associated with its use. The TBIMS NDB only includes individuals who were admitted to inpatient rehabilitation at a TBIMS local study site, thus findings may not generalize to individuals who are not appropriate for inpatient acute rehabilitation programs. Another limitation of the current study is the use of a dichotomous outcome variable for employment— i e., employed (including full- and part-time work, excluding supported employment) or not working. Although the focus of the current study is on competitive employment, the association between emotional functioning and successful participation in part-time work or supported employment should be the focus of future research. Lastly, as with many longitudinal studies, dropout related to a participant's characteristics may result in biases. Sander et al (2018) show retention in the TBIMS is related to race, drug or alcohol use, age, education, injury type, and discharge disposition. [38].

Conclusion

Much of the literature regarding return to work after TBI has focused on non-modifiable prognostic indicators, such as demographic, pre-injury functioning, and injury-related factors. When examining modifiable predictors, most studies have utilized a cross-sectional design and/or did not adjust for other key predictors. This study showed that after controlling for these baseline predictive variables, the experience of post-injury depression, which is a modifiable condition, contributes predictive ability to future employment outcomes. There are multiple, well-validated assessment tools that can screen for depression among individuals with TBI, and there are empirically-validated or promising pharmacological and psychotherapeutic interventions available. Incorporating these assessments and treatments into vocational rehabilitation programs could help promote favorable employment outcomes for individuals with moderate-to-severe TBI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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List of Abbreviations:

TBI	Traumatic Brain Injury
TBIMS	Traumatic Brain Injury Model Systems
PTA	Posttraumatic Amnesia
CT	Computed Tomography
PHQ-9	Patient Health Questionnaire – 9
IQR	Interquartile range
AUC	Area under the Receiver Operating Curve
SSRI	Selective Serotonin Reuptake Inhibitor

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Table 1:

Patient Characteristics (1-2 (N=2120), 1-5 (N=1844), 2-5 (N=2017) Total (N=2784))

Characteristic	Level	Overall (N(%), median(IQR))
Pre-Injury Employment	Yes	1703 (74.9%)
	No	572 (25.1%)
Age at Injury		32.0 (23.0-46.0)
Sex	Female	565 (24.8%)
	Male	1711 (75.2%)
Education	<HS/GED	384 (16.9%)
	HS/GED	828 (36.4%)
	>HS/GED	1064 (46.8%)
Student or Employed	Yes	1895 (83.4%)
	No	377 (16.6%)
Occupational Category	Professional	415 (18.3%)
	Skilled	924 (40.7%)
	Manual Labor	363 (16.0%)
	Unemployed	569 (25.1%)
Problem Alcohol Use	Yes	346 (15.7%)
	No	1860 (84.3%)
Illicit Drug Use	Yes	500 (22.1%)
	No	1759 (77.9%)
PTA Duration		23.0 (11.0-41.0)
Discharged in PTA	Yes	293 (12.9%)
	No	1983 (87.1%)
Initial Motor GCS		6.0 (4.0-7.0)
Elevated ICP	None	327 (14.5%)
	< 24 hours	230 (10.2%)
	> 24 hours	320 (14.2%)
	> 24 hours sustained	64 (2.8%)
	Not Monitored	1319 (58.4%)
Craniotomy	Yes	321 (14.1%)
	No	1955 (85.9%)
Craniectomy	Yes	211 (9.3%)
	No	2065 (90.7%)
CT Focal Hemorrhage	Yes	1794 (80.0%)
	No	450 (20.0%)
Acute Hospital LOS		18.0 (10.0-27.0)

Table 2:

Characteristics of Terminal Nodes for 2-year Employment

Node Number	Description	N (%)	2-Year Employment N (%)	1-Year Depression N (%)
6	4 Weeks in PTA, >HS education	114 (5%)	54 (47%)	37 (33%)
7	4 Weeks in PTA, ≤HS education	156 (7%)	45 (29%)	68 (44%)
9	Weeks in PTA >4, ≤HS education	491 (23%)	93 (19%)	199 (41%)
10	Weeks in PTA ≤3, Employed Pre-injury, >HS education	427 (20%)	290 (68%)	149 (35%)
11	Weeks in PTA ≤3, Employed Pre-injury, HS education	255 (12%)	149 (58%)	92 (36%)
12	Weeks in PTA ≤3, Employed Pre-injury, <HS education	82 (4%)	37 (45%)	38 (46%)
14	Weeks in PTA ≤3, Not employed Pre-injury, age 20-33	130 (6%)	44 (34%)	58 (45%)
15	Weeks in PTA ≤3, Not employed Pre-injury, age>33	116 (6%)	11 (10%)	71 (61%)
21	Weeks in PTA >4, >HS education, Discharged in PTA	75 (4%)	13 (17%)	27 (36%)
26	Weeks in PTA >4, >HS education, Not discharged in PTA, Employed pre-injury	221 (10%)	105 (48%)	82 (37%)
27	Weeks in PTA >4, >HS education, Not discharged in PTA, Not employed pre-injury	53 (3%)	13 (25%)	20 (38%)

Table 3:

Characteristics of Terminal Nodes for 5-Year Employment

Node	Description	N (%) (1-5)	Employment N (%) (5-year)	Depression N (%) (1-year)	N (%) (2-5)	Employment N (%) (5-year)	Depression N (%) (2-year)
6	PTA>4wks, ≤HS education	535 (31%)	138 (26%)	220 (41%)	610 (30%)	151 (25%)	250 (41%)
7	PTA≤4wks, >HS education, productive	609 (36%)	395 (65%)	213 (35%)	713 (36%)	459 (64%)	257 (36%)
8	PTA≤4wks, >HS education , Not productive	83 (5%)	17 (21%)	52 (63%)	105 (5%)	25 (24%)	54 (51%)
9	PTA≤4wks, <HS education , prof/ skilled job pre-injury	40 (2%)	17 (43%)	20 (50%)	50 (3%)	18 (36%)	23 (46%)
10	PTA≤4wks, <HS education, manual labor or unemployed pre-injury	67 (4%)	17 (25%)	37 (55%)	81 (4%)	24 (30%)	44 (54%)
12	PTA>7wks, >HS education	162 (9%)	60 (37%)	59 (36%)	184 (9%)	62 (34%)	65 (35%)
13	>HS education, PTA≤7wks, Age≤43yrs	163 (10%)	101 (62%)	53 (33%)	188 (9%)	108 (58%)	63 (34%)
14	>HS education, PTA≤7wks, Age>43yrs	59 (3%)	20 (34%)	22 (37%)	78 (4%)	29 (37%)	31 (40%)

(1-5) represents sample with complete data at both year-1 and year-5; (2-5) represents sample with complete data at both year-2 and year-5

Table 4:

AUC Values and 95% Confidence Interval for Each Model

Model[a]	1-year depression predicting 2-year employment	1-year depression predicting 5-year employment	2-year depression predicting 5-year employment
1: TNs, current emp [b]	0.872 (0.856, 0.880)	0.808 (0.787, 0.829)	0.829 (0.811, 0.848)
2: TNs, current emp, dep	0.878 (0.863, 0.894)	0.818 (0.797, 0.838)	0.838 (0.820, 0.856)
3: TNs, current emp, dep, dep*TN	0.880 (0.865, 0.895)	0.821 (0.800, 0.841)	0.841 (0.823, 0.859)

[a] TN=Terminal Node, dep=depression status, dep*TN=interaction between depression and terminal node.

[b] "Current emp" refers to employment at the time point used to predict future employment.

Table 5:

Comparison of AUC Values

Analysis	Model	Estimate [a]	p-value
1 predicting 2	2 vs. 1	0.61 (0.13, 1.11)	0.0132
1 predicting 5	2 vs. 1	0.96 (0.20, 1.71)	0.0130
2 predicting 5	2 vs. 1	0.92 (0.36, 1.47)	0.0011

[a]Difference in AUC values are $x10^{-2}$