Longitudinal Trajectories of Employment Among Adults with Moderate-to-Severe Traumatic Brain Injury

Ted Allaire

Department of Psychology, Eastern Michigan University
Department of Physical Medicine & Rehabilitation, University of Michigan

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Abstract

Introduction: Traumatic brain injury (TBI) is a major medical event that often yields a variety of adverse outcomes, including higher incidence of unemployment and diminished financial independence. While findings from previous studies have revealed considerable variability in the employment outcomes of adults with TBI, it remains unclear if there exist meaningfully distinct longitudinal patterns, or trajectories, of employment in the years following TBI. **Method:** We utilized growth curve analysis to estimate intercept and slope data pertaining to employment status over the first decade following TBI. We then subjected those intercept and slope data to two-step cluster analysis to identify distinct employment trajectory subgroups of individuals living with TBI. We then utilized multinomial logistic regression to identify predictors of trajectory membership. **Results:** Four employment trajectory clusters emerged. These were then visualized using graphing software and assigned the following labels: *stable unemployment*, *improving employment*, *stable employment*, and *deteriorating employment*. A variety of fixed and modifiable factors were found to significantly predict trajectory cluster membership. **Conclusion:** Unemployment after TBI is a common occurrence. However, there appear to be modifiable factors that, if intervened upon, may facilitate employment within this clinical population.

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Introduction

Moderate-to-severe traumatic brain injury (TBI) is a major health condition that yields a variety of functional impairments, including diminished workforce participation (Shames et al., 2007) and reduced financial independence (Hoofien et al., 2001). Review of epidemiological data indicates a lifetime prevalence of approximately 2.6% for these moderate-to-severe injuries (Corrigan et al., 2018). TBI exists on a spectrum of severity, ranging from mild (i.e., concussion), to moderate, to severe TBI (Malec et al., 2007). There is an inverse association between TBI severity and recovery of functional independence (Hammond et al., 2001), with most individuals with concussion returning to premorbid functional status within one month post-injury (Ryan & Warden, 2003).

This rapid course of recovery after concussion is contrasted by a much longer and more variable path for individuals with moderate-to-severe TBI (Novack et al., 2000). Many of the difficulties experienced by individuals with these more severe forms of TBI are either cognitive, affective, or behavioral in nature (Mazaux et al., 1997; McAllister, 2008). For example, cognitive difficulties commonly experienced by individuals with TBI, include inattention and slowed information processing speed (Lippert-Grüner et al., 2006), while common affective and behavioral sequelae include depressed mood and irritability (Jorge & Robinson, 2003). Depending on the severity of the injury, difficulties with basic arousal and consciousness may also be present (Schnakers & Monti, 2017). The psychological nature of these common sequelae underscores the importance of identifying psychological predictors of important functional outcomes within this population.

Recovery of function occurs both via the body healing its own damaged tissue as well as participation in comprehensive and interdisciplinary rehabilitation programs (Gordon et al., 2006). However, it is not uncommon for individuals with moderate-to-severe TBI to experience persistent cognitive and psychosocial difficulties. Of relevance to this study, these persistent cognitive difficulties may make it difficult for individuals with TBI to either return to previous employment or seek out new employment following their discharge from acute care (Wehman et al., 2005). As introduced above, individuals with TBI are at higher risk for unemployment than the general population (Doctor et al., 2005), and there appears to be a bidirectional link between quality of life and paid employment (Steadman-Pare et al., 2001), thus emphasizing the importance of maximizing workforce participation within this population.

On the topic of employment, several fixed and modifiable factors have been previously linked with differential employment outcomes after moderate-to-severe TBI. For example, Keyser-Marcus et al. (2002) reported that premorbid employment and being younger at time of injury both predicted higher likelihood of being employed at both short- and long-term follow-up. Findings from other studies have indicated that systematic forms of oppression, like institutionalized racism (Gary et al., 2009) and sexism (Corrigan et al., 2007), may also contribute to lower levels of workforce participation among people of color and women with TBI. Other, more directly modifiable factors, like poor cognitive (Franulic et al., 2004) and psychosocial (DiSanto et al., 2019) functioning, have also been found to predict lower rates of workforce participation after TBI. In all, there appears to be considerable variability in the employment outcomes of adults with TBI. Therefore, further clarifying, or segmenting, this heterogenous population into smaller, more homogenous subgroups may be useful in developing a more nuanced understanding of this diverse population.

To this last point, Cuthbert et al. (2015) did analyze the longitudinal trajectories of employment over the first 10 years following moderate-to-severe TBI. Findings from that study revealed that longitudinal patterns of employment for individuals with TBI were highly variable and impacted by a range of factors, with younger age, being White, and being male all predicting higher likelihood of employment. Of particular clinical utility, that research team developed an interactive tool, based on their findings, that allows for the probability of employment to be predicted contingent on a wide range of factors. While those study authors acknowledged the variability in employment after TBI and spoke to the possibility of using their data and interactive tool to identify distinct subgroups of individuals, it does not appear that they performed such an inquiry with their data.

Alternatively, DiSanto et al. (2019) did classify participants with TBI into subgroups based on longitudinal employment data (i.e., unstable, stable, or delayed employment or stable unemployment); however, those classifications were made manually (i.e., by researchers based on predetermined criteria) rather than statistically (e.g., algorithmically based on the actual structure of the data). DiSanto and colleagues' (2019) approach is contrasted by Ferdiana and colleagues (2014), who conducted a similar study of employment trajectories after spinal cord injury (SCI) in the Netherlands, in which that research team used growth mixture modeling (GMM) to identify longitudinal trajectories of employment after SCI. Use of GMM allowed those researchers to statistically discern meaningfully different trajectories of employment in the years after SCI. Together, the diverse methodologies utilized in these recent studies of employment after traumatic injury speaks to the wide range of analytic approaches that can be utilized to address these research questions.

Further clarifying the employment trajectories of individuals with TBI and identifying which factors impact those trajectories may allow clinicians and policymakers to more effectively maximize workforce participation within this clinical population. Accordingly, in this study, we identified the trajectories of employment followed by adults living with moderate-to-severe TBI in a manner similar to Cuthbert and colleagues (2015). We then extended the work of those authors by algorithmically segmenting study participants into distinct subgroups based on their unique employment trajectories. Lastly, we then examined the association between various fixed and modifiable factors and trajectory cluster membership. Findings from this study may complement the work of Cuthbert and colleagues (2015) by providing a description of both employment outcomes among adults living with moderate-to-severe TBI, as well as potential barriers and facilitators of employment within this population.

Aims and Hypotheses

The aims of this study were to identify employment trajectory subgroups among individuals with TBI and clarify which factors impact those employment trajectories.

Hypothesis 1. Individuals with TBI will be heterogenous in terms of employment. We hypothesized that multiple employment trajectory subgroups would emerge from within our data.

Hypothesis 2. A variety of factors will impact these employment trajectories. We hypothesized that, in general, greater TBI severity and both weaker cognitive and psychosocial functioning will correspond with a higher likelihood of unemployment.

Method

In this study, we performed secondary analysis of publicly available data stored within the National TBI Model Systems (TBIMS) Database, which is one of the largest repositories of data collected from individuals with TBI anywhere in the world. Data collected through the end of 2018 from patients at member TBIMS institutions have been made publicly available by the Traumatic Brain Injury Model Systems National Data and Statistical Center.

Participants

As of 2018, the National TBIMS Database contains longitudinal data collected from more than 15,000 adults living with TBI. Individuals are typically approached by TBIMS-associated staff during their initial hospitalization, post-injury. Attempts are then made to collect baseline data during participants' inpatient hospitalization. Subsequent attempts are later made to longitudinally collect data from each of these TBIMS enrollees at various intervals, including: one year post TBI, two years post TBI, five years post TBI, and every five years thereafter. The TBIMS began data collection in 1988, so, there are some TBIMS participants for whom data have been collected longitudinally for more than 30 years.

Measures

Injury characteristics and Acute Rehabilitation Factors. A variety of factors related to the severity of participants' TBI, as well as their initial participation in acute rehabilitation. For example, the number of days each participant spent in posttraumatic amnesia (PTA) was extracted from the TBIMS database. Similarly, days spent participating in acute rehabilitation were also obtained. Data pertaining to participants' extent of intracranial compression were extracted as well. This latter variable exists on an ordinal scale, including: (0) no midline shift, (1) midline shift of 1-5mm with cisterns present, (2) midline shift of 1-5mm with cisterns compressed, and (3) midline shift of greater than 5mm. Cognitive and motor functioning at discharge from acute rehabilitation were quantified using data derived from the Functional Independence Measure (FIM; Keith, 1987).

Demographics. Data pertaining to participant demographics were extracted from the TBIMS database as well. Demographic factors included: sex (female vs. male), race (Non-White vs. White), premorbid employment (not working vs. working), premorbid marital status (not married vs. married), and premorbid level of education (years of education).

Five-year Follow-up Data. Select data from five years post-TBI were also obtained from the TBIMS database. These included select follow-up data, like years of education and scores on the FIM motor and cognitive domains at long-term follow-up. Data from select psychometric instruments captured at long-term follow-up were also obtained. These included total scores on self-report measures of anxiety (Generalized Anxiety Disorder-7 [GAD-7]; Spitzer et al., 2006), depression (Patient Health Questionnaire-9 [PHQ-9]; Kroenke et al., 2001), and life satisfaction (Satisfaction with Life Scale [SWLS]; Diener et al., 1985). Each of these psychometric instruments have demonstrated adequate reliability and validity for use in this population.

Post-injury employment. Dichotomous data (not working vs. working) regarding participants' employment status were extracted from the TBIMS database. These data were extracted at various time points, including 1-, 2-, 5-, and 10-years post-TBI.

Procedures and Data Analytic Strategy

We utilized IBM SPSS and Amos to analyze the publicly available TBIMS dataset. Upon completion of initial data screening, cleaning, and other preliminary analyses, we used Amos to perform a growth curve analysis of participants' dichotomous employment data. We included participants' employment status at 1-, 2-, 5-, and 10-years post-TBI in this analysis. We then imputed the intercept and slope data gleaned from that analysis into SPSS, where we subjected those to two-step cluster analysis. Use of two-step cluster analysis provided a means of segmenting our larger sample of participants into unique and distinct subgroups based on their intercept (i.e., employment status at 1-year post-TBI) and slope (i.e., change in employment status over the first decade after injury). We then created a cluster membership variable for each participant included in this analysis. Using that cluster membership variable as a dependent variable, we then performed a multinomial logistic regression to clarify the association between select factors and covariates and trajectory membership.

Results

Preliminary Results

Analyses were performed in two phases. In the first, we performed growth curve modeling and two-step cluster analysis with a sample comprised of 2,651 adults living with moderate-to-severe TBI, for whom employment data were available at 1-, 2-, 5-, and 10-years post-TBI. In the second phase, we performed a multinomial logistic regression using data derived from a subsample of 753 participants from that larger Phase 1 sample for whom complete data were available for all relevant factors and covariates. Data regarding the composition of participants in Phases 1 and 2 can be found in Tables 1 and 2.

Table 1

Descriptive Statistics for Continuous Variables

Variable		*N (%)*	*M*	*SD*	*Min.*	*Max.*
Age at Injury (Years)						
	Phase 1	2651 (100.00%)	36.40	21.66	16	89
	Phase 2	753 (100.0%)	35.87	16.09	16	88
Premorbid Level of Education (Years)						
	Phase 1	2570 (96.94%)	12.57	2.67	1	20
	Phase 2	753 (100.0%)	13.03	2.54	1	20
FIM-Motor at Discharge from Acute Rehabilitation (Total Score)						
	Phase 1	2618 (98.76%)	69.40	17.50	13	91
	Phase 2	753 (100.0%)	73.39	12.86	19	91
FIM-Cognitive at Discharge from Acute Rehabilitation (Total Score)						
	Phase 1	2634 (99.36%)	24.47	6.54	5	35
	Phase 2	753 (100.0%)	26.19	4.74	11	35

Table 1 (continued)

	Variable	*N (%)*	*M*	*SD*	*Min.*	*Max.*
Length of Stay in Acute Rehabilitation (Days)						
	Phase 1	2579 (97.28%)	25.24	23.02	0	353
	Phase 2	753 (100.0%)	23.12	20.02	2	289
Length of Posttraumatic Amnesia (Days)						
	Phase 1	2148 (81.03%)	23.58	21.15	0	159

	Phase 2	753 (100.0%)	23.54	21.68	0	151
5-year Post-TBI: Generalized Anxiety Disorder-7 (Total Score)						
	Phase 1	1087 (41.00%)	3.84	5.04	0	21
	Phase 2	753 (100.0%)	3.85	5.04	0	21
5-year Post-TBI: Patient Health Questionniare-9 (Total Score)						
	Phase 1	1752 (66.09%)	4.94	5.64	0	27
	Phase 2	753 (100.0%)	4.98	5.59	0	27
5-year Post-TBI: Satisfaction with Life Scale (Total Score)						
	Phase 1	2283 (86.12%)	22.68	8.18	5	35
	Phase 2	753 (100.0%)	22.88	8.03	5	35
5-year Post-TBI: FIM-Motor (Total Score)						
	Phase 1	2590 (97.70%)	86.39	11.12	13	91
	Phase 2	753 (100.0%)	88.53	5.34	31	91
5-year Post-TBI: FIM-Cognitive (Total Score)						
	Phase 1	2595 (97.89%)	31.73	4.34	5	35
	Phase 2	753 (100.0%)	32.81	2.47	21	35

Table 2

Frequency Counts for Non-Continuous Variables

Variable		***N (%)***		
Sex		*Female*	*Male*	*Missing*
	Phase 1	748 (28.22%)	1903 (71.78%)	0 (0.00%)
	Phase 2	211 (28.02%)	542 (71.98%)	0 (0.00%)
Race		*Non-White*	*White*	*Missing*
	Phase 1	553 (20.86%)	1912 (72.12%)	186 (7.02%)
	Phase 2	154 (20.45%)	599 (79.55%)	0 (0.00%)

Table 2 (continued)

Variable		***N (%)***		
Premorbid Employment		*Not Working*	*Working*	*Missing*
	Phase 1	712 (26.86%)	1724 (65.03%)	215 (8.11%)
	Phase 2	185 (24.57%)	568 (75.43%)	0 (0.00%)
Marital Status		*Not Married*	*Married*	*Missing*

Phase 1	1773 (66.88%)	876 (33.04%)	2 (0.08%)
Phase 2	513 (68.13%)	240 (31.87%)	0 (0.00%)
Extent of Intracranial Compression	*No Visible Intracranial Compression*	*1-5mm Shift (Cisterns Present)*	
Phase 1	1465 (55.26%)	205 (7.73%)	
Phase 2	486 (87.73%)	68 (12.27%)	
	1-5mm Shift (Cisterns Compressed)	*>5mm Shift*	*Missing*
Phase 1	316 (11.92%)	298 (11.24%)	367 (13.84%)
Phase 2	104 (18.77%)	95 (17.15%)	0 (0.00%)

Trajectory Identification

Growth curve analysis yielded a model that adequately fit participants' employment data over the first decade after injury, $\chi^2(6) = 79.72$, $p < .001$, *TLI* = .98, *CFI* = .98, *RMSEA* = .07. We then imputed the estimated employment intercept and slope data into IBM SPSS, where we performed the remainder of our analyses.

Subgroup Identification

In SPSS, we subjected participants' employment intercept and slope data to two-step cluster analysis. Results of two-step cluster analysis initially revealed that a six-cluster solution appeared to best fit participants' employment intercept and slope data. This six-cluster solution appeared overfit to the data, as evidenced by four of the six clusters containing 10% or less than the overall sample. This overfitting was further evidenced by a high ratio of cases between the largest and smallest clusters (i.e., 7.94:1).

Accordingly, to address this overfitting, the two-step cluster algorithm was re-run with the number of clusters specified in this second analysis. In consideration of other fit indices (see Table 3), it was determined that a four-cluster solution offered an ideal balance between interpretive parsimony and model fit. More specifically, relatively lower BIC values were interpreted as indicators of enhanced relative fit, while silhouette coefficient values of 0.5 or higher were interpreted as indicators of adequate absolute fit. Intercept and slope centroid values for these four clusters are included in Table 4. A graphical depiction of the employment trajectories followed by members of each employment trajectory cluster is included in Figure 1.

Table 3

Fit Indices for the Various Cluster Solutions Fitted to Participants' Employment Intercept and Slope Data

Number of Clusters	BIC	BIC Change [a]	Ratio of BIC Changes [b]	Silhouette Coefficient [d]	Ratio of Cases [c]
1	3,705.60	null	null	null	null
2	2,088.82	-1,616.78	1.00	0.9	1.90
3	1,106.11	-982.71	0.61	0.7	2.44
4	677.83	-428.28	0.27	0.8	3.82
5	486.17	-191.66	0.12	0.8	5.31

6	342.70	-143.47	0.09	0.9	7.94
7	325.58	-17.12	0.01	0.9	12.56
8	330.93	5.35	0.00	0.9	12.56
9	336.90	5.97	0.00	0.9	16.84
10	352.81	15.91	-0.01	0.9	21.52

a. The changes are from the previous number of clusters in the table.
b. The ratios of changes are relative to the change for the two-cluster solution.
c. The ratios of cases are between the largest and smallest clusters.
d. Larger silhouette values reflect greater fit.

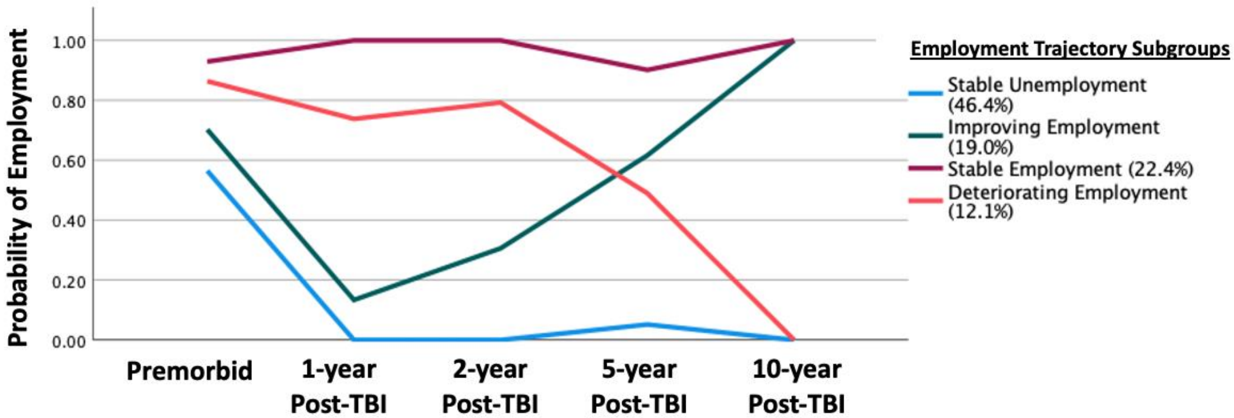
Table 4

Centroid Descriptive Statistics for Each Employment Trajectory Cluster

		Employment Intercept		**Employment Slope**	
	N	***M***	***SD***	***M***	***SD***
(1.) Stable Unemployment (46.4%)	1,231	0.57	0.20	-0.03	0.01
(2.) Improving Employment (19.0%)	505	0.86	0.06	0.00	0.00
(3.) Stable Employment (22.4%)	593	0.32	0.20	0.03	0.01
(4.) Deteriorating Employment (12.1%)	322	0.01	0.04	0.00	0.00
Combined	2,651	0.33	0.36	0.00	0.02

Figure 1

10-year Employment Trajectory Clusters Among Adults Living with Moderate-to-Severe Traumatic Brain Injury (n = 2,651)



Trajectory Subgroup Prediction

After identifying these trajectory subgroups, we then performed multinomial logistic regression to discern which factors impacted participants' likelihood of following a particular employment trajectory. As noted above, we performed these analyses using data derived from a subset of 753 participants from the larger Phase 1 sample for whom all relevant data were available.

Review of the data presented in Table 5 indicates that injury severity did not significantly predict trajectory membership, although duration of PTA did approach statistical significance. Alternatively, cognitive and motor functioning at discharge from acute rehabilitation, but not length of acute rehabilitation, both significantly contributed to model fit. With regard to premorbid and demographic factors, age at injury, premorbid employment status, and premorbid level of education each offered significant contributions to model fit. At 5-year follow up, level of education, life satisfaction, and cognitive functioning each contributed significantly to model fit.

Table 5

Results of Multinomial Logistic Regression Predicting Employment Trajectory Membership

	-2LL of Reduced Model	X2	DF	Sig.
Injury Characteristics and Acute Rehabilitation Factors				
Extent of Intracranial Compression (Ordinal Scale)	1460.54	4.97	3	0.17
Length of Posttraumatic Amnesia (Days)	1462.21	6.65	3	0.08
FIM-Motor at Discharge from Acute Rehabilitation (Total Score)	1486.60	*** 31.04	3	< .001
FIM-Cognitive at Discharge from Acute Rehabilitation (Total Score)	1471.93	*** 16.37	3	< .001
Length of Stay in Acute Rehabilitation (Days)	1461.76	6.20	3	0.10

Table 5 (continued)

	-2LL of Reduced Model	X2	DF	Sig.
Demographics				
Age at Injury (Years)	1559.88	*** 104.32	3	< .001
Sex (Female vs. Male)	1460.03	4.47	3	0.22
Race (Non-White vs. White)	1457.13	1.56	3	0.67
Premorbid Employment (Not Working vs. Working)	1511.08	*** 55.52	3	< .001
Marital Status (Not Married vs. Married)	1461.76	6.20	3	0.10
Premorbid Level of Education (Years)	1464.34	* 8.78	3	0.03
5-year Follow-Up Data				
5-year Post-TBI: Level of Education (Years)	1475.74	*** 20.17	3	< .001
5-year Post-TBI: Generalized Anxiety Disorder-7 (Total Score)	1458.24	2.67	3	0.45
5-year Post-TBI: Patient Health Questionniare-9 (Total Score)	1455.99	0.42	3	0.94
5-year Post-TBI: Satisfaction with Life Scale (Total Score)	1464.42	* 8.85	3	0.03
5-year Post-TBI: FIM-Motor (Total Score)	1463.15	7.59	3	0.06
5-year Post-TBI: FIM-Cognitive (Total Score)	1474.64	*** 19.08	3	< .001

Note. * $p < .05$, *** $p < .001$

Informed by these results, we performed a series of post hoc analyses to more precisely discern the unique associations between these factors and trajectory membership. These results are summarized in Table 6. Results of these post-hoc analyses were only examined and reported for predictors that contributed to initial model fit at either a significant ($p < .05$) or near-significant ($p < .10$) level. The stable unemployment cluster was used as a reference, from which all other clusters were compared. We made this decision because this was the largest of the employment trajectory clusters identified, and because stable unemployment seemed like the most appropriate trajectory to treat as a null hypothesis (i.e., not working).

Review of these post hoc data reveal that, relative to members of the steadily unemployed trajectory cluster, members of the improving employment cluster earned higher scores on the FIM Motor and Cognitive indices at both discharge from acute rehabilitation and at long-term follow-up. These individuals also tended to be younger, have lower levels of premorbid education, and were less likely to have been employed at the time of their injury. While less educated at the time of their injuries, individuals who tended to follow this improving education trajectory were more educated than members of the stable unemployment cluster at 5-years post-TBI.

Similarly, members of the stable employment trajectory cluster also outperformed members of the stable unemployment trajectory on the FIM Motor and Cognitive indices at discharge from acute rehabilitation. This pattern emerged with respect to scores on the FIM Cognitive index, but not the FIM Motor index, at long-term follow-up as well. Shorter duration of PTA also predicted a higher likelihood of belonging to the stable employment trajectory cluster, while extent of intracranial compression did not. Again, duration of PTA contributed to overall model fit at a near-significant level. Younger age at injury and premorbid employment both predicted a higher likelihood of belonging to this employment trajectory, but not premorbid level of education. However, level of education at 5-years post-injury did significantly predict a higher likelihood of belonging to this trajectory cluster. Higher levels of life satisfaction at 5-

years post-TBI also predicted a higher likelihood of belonging to this trajectory cluster, relative to the stable unemployment cluster.

In comparison to the improving employment and stable employment trajectory clusters, there were fewer factors that distinguished the deteriorating employment and stable unemployment clusters. Like its predecessors, higher scores on the FIM Motor and Cognitive indices at discharge from acute rehabilitation both predicted a significantly higher likelihood of belonging to this trajectory cluster. Being employed at the time of injury also predicted a significantly higher likelihood of belonging to this cluster.

A more general overview of each employment trajectory cluster's composition is included in Table 7.

Table 6

Results of Multinomial Logistic Regression Post Hoc Analysis

Improving Employment (19.0%) [a]	**B**	**SE**	**Wald**	**DF**	**Sig.**	**Exp(B)**
Injury Characteristics and Acute Rehabilitation Factors						
FIM-Motor at Discharge from Acute Rehabilitation (Total Score)	0.02	0.01	4.14	1.00	0.04	* 1.02
FIM-Cognitive at Discharge from Acute Rehabilitation (Total Score)	0.10	0.03	15.06	1.00	< 0.001	*** 1.11
Demographics						
Age at Injury (Years)	-0.09	0.01	63.57	1.00	< 0.001	*** 0.92
Premorbid Level of Education (Years)	-0.29	0.11	6.61	1.00	0.01	* 0.75
Premorbid Employment (Not Working)	-0.60	0.28	4.55	1.00	0.03	* 0.55
Premorbid Employment (Working)	0 [b]	.	.	0.00	.	.
5-Year Follow-Up Data						
5-year Post-TBI: Level of Education (Years)	0.46	0.11	16.26	1.00	< 0.001	*** 1.58
5-year Post-TBI: FIM-Motor (Total Score)	0.06	0.03	4.50	1.00	0.03	* 1.06
5-year Post-TBI: FIM-Cognitive (Total Score)	0.17	0.07	7.07	1.00	0.01	* 1.19
Stable Employment (22.4%) [a]	**B**	**SE**	**Wald**	**DF**	**Sig.**	**Exp(B)**
Injury Characteristics and Acute Rehabilitation Factors						
FIM-Motor at Discharge from Acute Rehabilitation (Total Score)	0.06	0.01	26.25	1.00	< 0.001	*** 1.06
FIM-Cognitive at Discharge from Acute Rehabilitation (Total Score)	0.07	0.03	6.78	1.00	0.01	* 1.08
PTA Length (Days)	-0.02	0.01	4.20	1.00	0.04	* 0.98
Demographics						
Age at Injury (Years)	-0.07	0.01	46.01	1.00	< 0.001	*** 0.93
Premorbid Employment (Not Working)	-2.26	0.38	35.57	1.00	< 0.001	*** 0.11
Premorbid Employment (Working)	0 [b]	.	.	0.00	.	.
5-Year Follow-Up Data						
5-year Post-TBI: Level of Education (Years)	0.37	0.12	9.42	1.00	< 0.001	*** 1.44
5-year Post-TBI: Satisfaction with Life Scale (Total Score)	0.06	0.02	8.33	1.00	< 0.001	*** 1.06
5-year Post-TBI: FIM-Cognitive (Total Score)	0.32	0.08	16.45	1.00	< 0.001	*** 1.37
Deteriorating Employment (12.1%) [a]	**B**	**SE**	**Wald**	**DF**	**Sig.**	**Exp(B)**
Injury Characteristics and Acute Rehabilitation Factors						
FIM-Motor at Discharge from Acute Rehabilitation (Total Score)	0.04	0.01	9.33	1.00	< 0.001	*** 1.04
FIM-Cognitive at Discharge from Acute Rehabilitation (Total Score)	0.07	0.03	4.90	1.00	0.03	* 1.07
Demographics						
Premorbid Employment (Not Working)	-1.57	0.37	18.18	1.00	< 0.001	*** 0.21
Premorbid Employment (Working)	0 [b]	.	.	0.00	.	.

Note. * $p < .05$, *** $p < .001$

a. The reference category is: Stable Unemployment (46.4%)

b. This parameter is set to zero because it is redundant.

Table 7

Descriptive Statistics for Each of the Employment Trajectory Clusters Identified

	N	*M*	*SD*	*Min.*	*Max.*
Age at Injury (Years)					
(1.) Stable Unemployment (46.4%)	286	42.92	17.14	16	88
(2.) Improving Employment (19.0%)	177	26.44	10.44	16	64
(3.) Stable Employment (22.4%)	197	31.80	11.92	16	68
(4.) Deteriorating Employment (12.1%)	93	40.77	17.60	16	87
Premorbid Level of Education (Years)					
(1.) Stable Unemployment (46.4%)	286	12.57	2.65	4	20
(2.) Improving Employment (19.0%)	177	12.94	2.22	3	20
(3.) Stable Employment (22.4%)	197	13.52	2.60	1	20
(4.) Deteriorating Employment (12.1%)	93	13.58	2.39	8	20
FIM-Motor at Discharge from Acute Rehabilitation (Total Score)					
(1.) Stable Unemployment (46.4%)	286	69.37	13.92	19	91
(2.) Improving Employment (19.0%)	177	73.29	12.89	27	91
(3.) Stable Employment (22.4%)	197	78.36	10.10	44	91
(4.) Deteriorating Employment (12.1%)	93	75.46	10.39	49	91
FIM-Cognitive at Discharge from Acute Rehabilitation (Total Score)					
(1.) Stable Unemployment (46.4%)	286	25.19	4.73	11	35
(2.) Improving Employment (19.0%)	177	26.74	4.93	14	35
(3.) Stable Employment (22.4%)	197	27.01	4.45	15	35
(4.) Deteriorating Employment (12.1%)	93	26.54	4.51	13	35
Length of Stay in Acute Rehabilitation (Days)					
(1.) Stable Unemployment (46.4%)	286	26.18	24.31	2	289
(2.) Improving Employment (19.0%)	177	24.73	18.54	3	97
(3.) Stable Employment (22.4%)	197	17.90	14.35	2	94
(4.) Deteriorating Employment (12.1%)	93	21.72	15.90	3	86
Length of Posttraumatic Amnesia (Days)					
(1.) Stable Unemployment (46.4%)	286	27.61	25.20	0	151
(2.) Improving Employment (19.0%)	177	24.49	20.72	0	123
(3.) Stable Employment (22.4%)	197	16.85	14.53	0	96
(4.) Deteriorating Employment (12.1%)	93	23.40	21.35	0	117
Sex (Percent Male)					
(1.) Stable Unemployment (46.4%)	286	0.67	0.47	0	1
(2.) Improving Employment (19.0%)	177	0.73	0.45	0	1
(3.) Stable Employment (22.4%)	197	0.81	0.40	0	1
(4.) Deteriorating Employment (12.1%)	93	0.68	0.47	0	1

	N	*M*	*SD*	*Min.*	*Max.*
Premorbid Employment (Percent Working)					
(1.) Stable Unemployment (46.4%)	286	0.61	0.49	0	1
(2.) Improving Employment (19.0%)	177	0.72	0.45	0	1
(3.) Stable Employment (22.4%)	197	0.93	0.25	0	1
(4.) Deteriorating Employment (12.1%)	93	0.87	0.34	0	1
Premorbid Marital Status (Percent Married)					
(1.) Stable Unemployment (46.4%)	286	0.37	0.48	0	1
(2.) Improving Employment (19.0%)	177	0.15	0.36	0	1
(3.) Stable Employment (22.4%)	197	0.35	0.48	0	1
(4.) Deteriorating Employment (12.1%)	93	0.41	0.49	0	1
5-year Post-TBI: Level of Education (Years)					
(1.) Stable Unemployment (46.4%)	286	12.89	2.52	4	20
(2.) Improving Employment (19.0%)	177	13.97	2.21	3	20
(3.) Stable Employment (22.4%)	197	14.20	2.38	8	20
(4.) Deteriorating Employment (12.1%)	93	13.86	2.42	8	20
5-year Post-TBI: FIM-Motor (Total Score)					
(1.) Stable Unemployment (46.4%)	286	86.35	6.50	44	91
(2.) Improving Employment (19.0%)	177	89.63	5.00	31	91
(3.) Stable Employment (22.4%)	197	90.44	2.68	56	91
(4.) Deteriorating Employment (12.1%)	93	89.10	3.79	64	91
5-year Post-TBI: FIM-Cognitive (Total Score)					
(1.) Stable Unemployment (46.4%)	286	31.73	2.88	21	35
(2.) Improving Employment (19.0%)	177	33.28	1.96	27	35
(3.) Stable Employment (22.4%)	197	33.91	1.38	30	35
(4.) Deteriorating Employment (12.1%)	93	32.90	2.47	23	35
5-year Post-TBI: Generalized Anxiety Disorder-7 (Total Score)					
(1.) Stable Unemployment (46.4%)	286	4.84	5.72	0	21
(2.) Improving Employment (19.0%)	177	3.73	4.67	0	21
(3.) Stable Employment (22.4%)	197	2.57	3.94	0	21
(4.) Deteriorating Employment (12.1%)	93	3.71	4.99	0	18
5-year Post-TBI: Patient Health Questionniare-9 (Total Score)					
(1.) Stable Unemployment (46.4%)	286	6.38	6.11	0	25
(2.) Improving Employment (19.0%)	177	4.71	5.17	0	27
(3.) Stable Employment (22.4%)	197	3.25	4.58	0	22
(4.) Deteriorating Employment (12.1%)	93	4.86	5.62	0	24

Table 7 (continued)

	N	*M*	*SD*	*Min.*	*Max.*		*N*	*M*	*SD*	*Min.*	*Max.*

Race (Percent White)					
(1.) Stable Unemployment (46.4%)	286	0.73	0.44	0	1
(2.) Improving Employment (19.0%)	177	0.79	0.41	0	1
(3.) Stable Employment (22.4%)	197	0.88	0.33	0	1
(4.) Deteriorating Employment (12.1%)	93	0.83	0.38	0	1
Extent of Intracranial Compression (Ordinal Scale)					
(1.) Stable Unemployment (46.4%)	286	0.88	1.20	0	3
(2.) Improving Employment (19.0%)	177	0.59	1.01	0	3
(3.) Stable Employment (22.4%)	197	0.74	1.11	0	3
(4.) Deteriorating Employment (12.1%)	93	0.63	0.95	0	3

5-year Post-TBI: Satisfaction with Life Scale (Total Score)					
(1.) Stable Unemployment (46.4%)	286	20.57	8.46	5	35
(2.) Improving Employment (19.0%)	177	23.13	7.35	5	35
(3.) Stable Employment (22.4%)	197	25.97	6.58	5	35
(4.) Deteriorating Employment (12.1%)	93	23.00	8.52	5	35

Discussion

In this study we identified four distinct trajectories of employment followed by adults living with moderate-to-severe TBI in the United States. The largest trajectory cluster identified included nearly half of the 2,651 participants from Phase 1 and was characterized by a pattern of stable unemployment. The second largest cluster identified included approximately one-fifth of Phase 1 participants and was characterized by a pattern of stable employment. The next largest cluster also included approximately one-fifth of Phase 1 participants, with members tending to follow an improving employment trajectory. Of note, members of this trajectory were nearly just as likely to be employed at 10-years post TBI as members of the stable employment trajectory. Finally, the least populous trajectory included slightly more than 10% of Phase 1 participants and was characterized by a pattern of steadily decreasing employment probability.

We also identified a variety of fixed and modifiable factors that impacted participants' likelihood of following one of these trajectories relative to the stable unemployment trajectory. Fixed factors identified included participant age at injury and both premorbid level of education and employment status. Semi-modifiable factors identified included functional independence at both discharge from acute rehabilitation and long-term follow-up. More directly modifiable factors identified included level of education and life satisfaction at 5-years post-injury. We observed that duration of PTA, which can be interpreted as an indicator of TBI severity, predicted trajectory membership at a near-significant level.

Our findings map onto the existing literature in several ways. For example, like Keyser-Marcus et al. (2002), we observed that being employed at the time of injury yielded a significantly higher likelihood of not belonging to the stable unemployment trajectory cluster. Similarly, younger age at injury also predicted a significantly higher likelihood of either belonging to the stable employment or improving employment trajectories.

This finding is further contextualized by the observation that, relative to the stable unemployment group, members of the improving employment trajectory exhibited significantly lower educational attainment at baseline but significantly greater educational attainment at 5-years post-TBI. Higher educational attainment at long-term follow-up also predicted a significantly higher likelihood of belonging to the stable employment trajectory cluster. In consideration of these data, it appears that younger adults with lower baseline educational attainment may specifically benefit from pursuing additional education and training in the years following their injury. This benefit appears to be quite pronounced, with nearly all 505 members of this improving employment trajectory cluster being employed one decade after injury. Identifying ways to incentivize education participation for members of this clinical population may be a useful policy intervention to facilitate greater employment among individuals with moderate-to-severe TBI.

Furthermore, we did not observe a significant association between participant race or sex on employment trajectory membership. This diverges from findings from previous studies, which have indicated that systemic barriers, like racism and sexism, may differentially impact employment outcomes for adults with TBI (Corrigan et al., 2007; Gary et al., 2009). While imaging data did not significantly predict trajectory membership, shorter duration of PTA, an indicator of less severe TBI, did predict a significantly higher likelihood of belonging to the stable employment trajectory. Other factors found to have a null effect on employment trajectory membership included premorbid marital status and both depression and anxiety severity at long-term follow-up.

With regard to this latter finding, while neither depression nor anxiety at 5-years post-TBI significantly impacted trajectory membership, life satisfaction did. More specifically, greater life satisfaction at 5-years post-TBI significantly predicted a higher likelihood of belonging to the stable employment trajectory. Because these data are longitudinal and because life satisfaction was measured at the midpoint of longitudinal data collection, it seems most plausible that enhanced life satisfaction is a benefit of stable employment over the first 5 years post-TBI and, perhaps, a facilitator of employment at one-decade post-injury. Regarding this latter point, it is worth noting that life satisfaction did not predict a significantly higher likelihood of belonging to the improving employment trajectory cluster, which was just as likely to be employed at 10-year follow-up. This seems to support the idea that enhanced life satisfaction may be a benefit of stable employment, more than a facilitator of future employment.

Of relevance to the sponsor of this project, it may be useful to contextualize these findings in relation to the results of various demonstration projects led by the U.S. Social Security Administration (SSA). To this point, review of relevant demonstration project findings described in the recently published *Lessons from SSA Demonstrations for Disability Policy and Future Research*, indicates that SSA-sponsored intervention programming designed to address some of the abovementioned intervention targets has shown promise in helping to facilitate workforce participation for disabled adults. Building on the results of those projects, findings from this archival study may help to inform the direction of future demonstration projects initiated by the SSA.

Limitations

Our findings are limited by a number of factors. For example, use of a non-fuzzy clustering approach required study participants to belong absolutely to only one employment trajectory cluster. Alternatively, had we utilized fuzzy clustering in this study, then participant cluster (or class) membership would have been probabilistic, rather than absolute. While this alternative approach may have afforded a slightly more nuanced understanding of the employment trajectories followed by study participants, it is thought that use of more traditional cluster analysis yielded more directly interpretable data. Similarly, many fuzzy clustering approaches require advanced statistical knowledge and software fluency, whereas our approach relies on analyses and algorithms included in most basic statistical software packages. This latter point, ideally, enhances the replicability of our data analytic approach for researchers conducting similar studies in the future.

While use of data derived from the TBIMS database made this project feasible, it does slightly skew the population that our study sample represents. That is, by definition, individuals participating in the TBIMS have received acute care and rehabilitation within a model program in the United States that specializes in treatment of TBI. Many individuals with TBI, including many individuals residing outside the United States, receive their acute care and rehabilitation in less specialized programs. Replicating our methodology in a more diverse sample may further contextualize the findings from this study and yield additional information useful in maximizing workforce participation among adults living with moderate-to-severe TBI.

Conclusion

Our findings mirror results from previous studies pointing to the heterogeneity of employment trajectories followed by adults living with moderate-to-severe TBI. In all, our findings indicated that nearly half of the participants in this study did not return to work in the first decade after injury, while slightly more than half were unemployed at 10-years post-TBI. This means that nearly half of the participants in this study were employed at 10-years post-TBI, with approximately one-fifth of study participants following a trajectory of stable employment over the first decade post-injury. These findings underscore the importance of continuing to prioritize research on employment outcomes within this population.

A series of fixed (e.g., premorbid education and employment) and modifiable factors (e.g., functional independence and post-injury educational attainment) appear to correspond significantly with employment outcomes among this population. Our data highlight potential facilitators (i.e., greater educational attainment) and benefits (i.e., greater life satisfaction) of paid employment in the years following TBI. Building on this project, a next step in this program of research would be to measure the impact on workforce participation of intervening upon these modifiable factors. Findings from future projects informed by this study may yield actionable recommendations for policy makers and others involved in policy development.

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