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ORIGINAL RESEARCH

Family Involvement in Traumatic Brain Injury Inpatient Rehabilitation: A Propensity Score Analysis of Effects on Outcomes During the First Year After Discharge

Jennifer Bogner, PhD, FACRM,[a,*] Erinn M. Hade, PhD,[a,*] Juan Peng, MAS,[a] Cynthia L. Beaulieu, PhD, ABPP,[a,b] Susan D. Horn, PhD,[c] John D. Corrigan, PhD,[a] Flora M. Hammond, MD, FACRM,[d] Marcel P. Dijkers, PhD, FACRM,[e,f] Erin Montgomery, MS, CCC-SLP,[a] Kamie Gilchrist, MS, CCC-SLP,[g] Clare Giuffrida, PhD,[h] Aubrey Lash, CTRS,[i] Misti Timpson, DPT, NCS[j]

From the [a]The Ohio State University College of Medicine, Columbus, OH; [b]Brooks Rehabilitation Hospital, Jacksonville, FL; [c]University of Utah School of Medicine, Salt Lake City, UT; [d] Indiana University School of Medicine, Indianapolis, IN; [e]Icahn School of Medicine at Mount Sinai, New York, NY; [f]Wayne State University, Detroit, MI; [g]Intermountain Medical Center, Murray, UT; [h]Rush University Medical Center, Chicago, IL; [i]Cleveland VA Medical Center, Cleveland, OH; and [j]Rocky Mountain University of Health Professions, Provo, UT.

[*]Hade and Bogner contributed equally to this work.

Abstract

Objective: To evaluate the effect of family attendance at inpatient rehabilitation therapy sessions on traumatic brain injury (TBI) patient outcomes at discharge and up to 9 months postdischarge.

Design: Propensity score methods are applied to the TBI Practice-Based Evidence database, a database consisting of multisite, prospective, longitudinal, and observational data.

Setting: Nine inpatient rehabilitation centers in the United States.

Participants: Patients (N=1835) admitted for first inpatient rehabilitation after an index TBI.

Intervention: Family attendance during therapy sessions.

Main Outcome Measures: Participation Assessment for Recombined Tools-Objective-17 (Total scores and subdomain scores of Productivity, Out and About, and Social Relations), Functional Independence Measure, Satisfaction with Life Scale, and Patient Health Questionnaire-9.

Results: Participants whose families were in attendance for at least 10% of the treatment time were more out and about in their communities at 3 and 9 months postdischarge than participants whose families attended treatment less than 10% of the time. Although findings varied by propensity score method, improved functional independence in the cognitive area at 9 months was also associated with increased family attendance.

Conclusions: Family involvement during inpatient rehabilitation may improve community participation and cognitive functioning up to 9 months after discharge. Rehabilitation teams should engage patients' families in the rehabilitation process to maximize outcomes.

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What is the benefit for patients when families are involved in acute inpatient rehabilitation? A simple answer to this question remains elusive, particularly for adult traumatic brain injury (TBI) inpatient rehabilitation. Presumably, family attendance during inpatient rehabilitation sessions facilitates better family understanding of the effects of and deficits associated with the TBI to help prepare them for modifications and adaptations that will need to be made after the person with TBI returns home. Family members can also help therapists identify functional activities that the individual will likely be doing after returning home, so that these activities can be incorporated into treatment.[1] However, the family is coping with numerous stressors throughout the rehabilitation admission.[2] Other matters require attention, such as making alternative arrangements at work to allow them to supervise their family member when they return home. Given the plethora of competing priorities families must juggle, therapists understandably grapple with determining how strongly they should encourage families to attend rehabilitation treatment sessions.[2,3]

An estimate of the effects of family involvement on the rehabilitation outcomes of the patient would assist with decision making regarding family attendance in therapy. Most of the currently available evidence is indirect at best. For example, in the pediatric rehabilitation literature, parent training has been found to have a positive influence on the child's outcomes.[4,5] In the adult literature, studies of postacute outpatient rehabilitation suggest that family involvement in rehabilitation can have an effect on the therapeutic alliance, indirectly affecting outcome.[6] Family engagement in postacute rehabilitation has also been found to be associated with greater optimism and better emotional health of family members.[7] These latter findings have driven the development of interventions to assist with family adjustment.[8]

One study directly evaluated the relation between family attendance at inpatient speech therapy sessions.[9] The study used the Traumatic Brain Injury Practice-Based Evidence (TBI-PBE) multicenter database, which is a collection of data from each rehabilitation treatment session using point-of-care (POC) forms to document treatment activities and persons who participated in each session.[10] McElroy and Dijkers[9] investigated the effect of the percentage of speech therapy sessions conducted with family present on length of stay and cognitive-communication functional outcome as measured by the Rasch-adjusted cognitive FIM gain. Family presence was found to be a significant predictor of cognitive FIM gain.

The current study uses the same database to evaluate the effect of family member attendance during any of the inpatient rehabilitation therapy sessions, comparing the outcomes of patients whose families attended with those of patients whose families did not attend or attended very little. We hypothesize that patients whose families attend therapy for a substantive amount of time will experience better community participation, functional independence, and subjective well-being at discharge and during the year after discharge from rehabilitation.

List of abbreviations:

95% CI	**95% confidence interval**
ASD	**absolute standardized difference**
CSI	**Comprehensive Severity Index**
FI	**family involvement**
PART-O	**Participation Assessment with Recombined Tools-Objective**
PHQ-9	**Patient Health Questionnaire-9**
POC	**point of care**
TBI	**traumatic brain injury**
TBI-PBE	**Traumatic Brain Injury Practice-Based Evidence study**

Methods

The TBI-PBE multicenter dataset was compiled from 2008 to 2011 to include a wide array of patient characteristics, details of rehabilitation interventions and medical course, and outcomes.[10] Data were abstracted from medical records and from POC forms completed by therapists after each rehabilitation session. The Institutional Review Board at each center approved the study; each patient or their proxy gave informed consent.

Participants

To be enrolled in the TBI-PBE study, patients were required to be 14 years of age or older and to have sustained a TBI for which they were receiving their first exposure to inpatient care on the designated brain injury unit of one of the participating rehabilitation facilities. For the purposes of the current study, they must have received treatment at 1 of the 9 United States sites (the Canadian site was excluded from this analysis due to substantive differences in its rehabilitation program). Because the first 3 days of rehabilitation were used to complete the baseline assessments[11] that yielded confounders in the current study, participants were required to have a length of stay of at least 4 days to be included in the analysis (supplemental fig S1, available online only at http://www.archives-pmr.org/).

Family involvement in rehabilitation

Data on family attendance were obtained from the POC forms. Family involvement (FI) was operationalized as attendance by any family member or friend during at least 10% of all treatment minutes provided by occupational, physical, speech, or recreational therapists, or by psychologists (see supplemental appendix S1 for additional details regarding calculation, available online only at http://www.archives-pmr.org/). The cutoff of 10% was determined by evaluating the distribution of percent of session time across all disciplines and days of the stay family attended, which was found to be highly skewed but best characterized as a dichotomy between those with none or minimal family involvement versus patients with *substantive* (≥10%) family involvement.

Outcomes

Outcomes included community participation, functional independence, and subjective well-being. All of the outcomes were measured at 3 and 9 months postdischarge from rehabilitation; functional independence was also measured at discharge. The measures used to assess the outcomes have been found to be reliable and valid when used with persons with TBI.[12-28] The primary outcome, participation, was measured with the Participation Assessment for Recombined Tools-Objective-17 (PART-O-17) at 9 months.[15] It has a total score based on 3 subdomain scores (Out and About, Productivity, Social Relations), as well as a Rasch-derived total score reflecting participation as a unidimensional construct.[29] Additional outcome measures included the Rasch-transformed FIM Cognitive and Motor scores,[21,22] Satisfaction with Life Scale,[23] and the Patient Health Questionnaire-9 (PHQ-9).[24] The PHQ-9 was scored as a dichotomous variable (no depressive disorder vs likely depressive disorder).[26] Measures of subjective well-being were only completed by the person with TBI, whereas the objective measures could be completed by a proxy if the person with TBI was unable to participate in the follow-up interview(s).

Potential confounders and prognostically important variables

Data collection, described in detail in previous publications,[10] also involved abstraction from medical records by personnel trained to criterion. Only variables that were unlikely to be influenced by FI in rehabilitation were considered as potential confounders or prognostically important variables, and therefore only those that were measured before or at rehabilitation admission (first 3d[13]) were included in the propensity score model. The Comprehensive Severity Index (CSI)-brain injury was used to reflect severity of brain-related conditions, whereas the CSI-nonbrain injury score reflected severity of all other medical conditions.[10,30] The full list of potential confounders can be found in supplemental appendixes S2 and S3 (available online only at http://www.archives-pmr.org/).

Data analyses

Data were analyzed using SAS version 9.3[a] and Stata version 14.0.[b] Propensity score matching and inverse probability treatment weighting (IPTW) by the estimated propensity score were used to control confounders. The propensity score (*e*), the probability of FI≥10% conditional on baseline covariates, was estimated through a logistic regression model. Nearest neighbor 1:1 without replacement matching by the propensity score within a predetermined caliper width (of .01) helped to ensure the 2 FI groups contained participants with similar covariate values. Because 1:1 matching excludes some nonexposed, and potentially exposed, participants, we also used IPTW by the odds and compared the point and variance estimates obtained through matching. Both the matching and the weighting methods estimated the average treatment effect on the treated.[31] Adequacy of balance between FI groups for each potential confounder was assessed using multiple diagnostics.[31,32] For continuous and categorical covariates, the absolute standardized differences (ASDs) (the difference in means between groups divided by the pooled standard deviation) were compared before and after matching or IPTW. In addition, for continuous covariates, variance ratios and graphical evaluation of covariate distributions were appraised. Standardized differences below 0.10, and variance ratios between 0.80 and 1.20 were considered to be in our target balance diagnostic ranges. Multiple propensity score models were considered, including exploration of interaction and higher order terms, until the best possible balance was achieved.

Marginal regression models using generalized estimating equations with a robust sandwich type variance estimator were used to estimate the average treatment effect on the treated. All models estimated the effect of FI and adjusted for any covariates that did not meet the balance criteria. For the full cohort analysis, we also adjusted for covariates thought to have a sufficient influence on outcomes to warrant additional control in the outcome analysis (FIM Cognitive at admission, FIM Motor at admission, age, CSI brain injury and CSI for nonbrain injury [both at admission], high school or greater education, previous brain injury, whether post-traumatic amnesia cleared prior to rehabilitation admission, midline shift, premorbid impulse control problem, premorbid anxiety, or depressed mood).

Multiple imputation (40 iterations), by chained equations with predictive mean matching or K-nearest neighbors, of missing outcome data tested the extent to which missing outcomes might affect inferential findings. Heterogeneity of treatment effect was evaluated by stratifying the sample into 2 subgroups: Severe and Less Severe TBI. The Severe subgroup was defined as patients who were admitted with FIM Motor scores<28.75 and FIM Cognitive scores at admission≤15, n=820 (case mix group levels 206 or 207). The Less Severe subgroup consisted of the remainder of the sample (n=1015).

Results

A total of 1843 participants provided at least 1 outcome data point (see supplemental fig S1), with 905 receiving FI≥10%, and 938 receiving FI<10%. Only 1835 participants were used in the outcome analysis due to 8 participants missing covariate data. As shown in table 1 and supplemental appendixes S2 and S3, patients who received FI≥10% were more likely to be younger, white, not insured by Medicare, and injured in a moving vehicle crash (and not a fall). Some site differences were also observed. Prior to matching or weighting, substantial inbalance was observed: (1) the ASD of the confounders ranged from .00 to .53 (average .15), with 59% (53/90) of the confounders having ASD>.10; and (2) variance ratios ranged from .68 to 1.33, with 3 variables being outside the criterion range.

Full cohort analysis

Close matches, within our caliper distance, were not found for 821 participants and therefore they were not included in the matched analysis. Those not included in the matched analyses tended to be older, not driving, previously married, retired, and had a higher FIM Motor score at admission (all $P<.05$). IPTW allowed use of the full sample. The balance diagnostics after using each propensity score method were excellent: (1) ASDs with matching ranged from .00 to .09 (average .03); (2) ASDs using IPTW ranged from 0.00 to 0.10 (averaging .03); (3) for both methods, only the variance ratio for days from injury to rehabilitation admission fell outside of the criterion window; and (4) for both methods, the distributions of the continuous variables were comparable (see supplemental appendixes S2 and S3) and the area of common support was excellent.

Regression models for matched and IPTW analyses estimated the effect of FI, adjusted for days from injury to rehabilitation admission, and the additional theoretically influential variables. As shown in table 2, consistent positive and significant ($P<.05$) findings by both propensity score methods were identified for PART-O Out and About at 3 and 9 months. FI≥10% was associated with an increase in PART-O Out and About at 3 months of 0.11 points (95% confidence interval [95% CI], 0.01-0.21, by both methods) and between 0.12 (IPTW, 95% CI, 0.02-0.22) and 0.15 (matched, 95% CI, 0.05-0.25) points at 9 months. The PART-O Total and Total Rasch 3 and 9 month scores also suggested positive effects with increased FI; however, PART-O total effect sizes are generally smaller than Out and About (ranging between 0.07 and 0.10 points) and the *P* values ranged from .01 to .16 (with 1 *P* value=.31).

Table 1 Demographic and clinical characteristics of full cohort at admission, by FI, prior to and with matching and weighting

	Before PSM			Matched			Weighted		
Characteristics	FI<10% n=938	FI≥10% n=905	ASD	FI≤10% n=507	FI>10% n=507	ASD	FI<10% n=936	FI≥10% n=905	ASD
Demographics									
Age at admission Mean ± SD	49.5±21.8	39.1±19.7	0.50	43.5±21.1	43.8±21.3	0.01	38.9±19.6	39.1±19.7	0.01
Male sex %	70.8	72.9	0.05	73.0	72.4	0.01	71.6	72.9	0.03
Race/ethnicity %									
White non-Hispanic	69.7	81.9	0.29	76.5	77.1	0.01	82.7	81.9	0.02
White Hispanic	7.8	4.5	0.14	5.3	5.7	0.02	3.9	4.5	0.03
Black	19.5	10.7	0.25	15.8	14.4	0.04	10.8	10.7	0.00
Other or unknown race/ethnicity	3.0	2.9	0.01	2.4	2.8	0.03	2.5	2.9	0.02
At least high school education %	68.8	76	0.16	73.0	72.6	0.01	76.3	76.0	0.01
Insurance %									
MCO/HMO	9.9	21.4	0.32	15.0	14.6	0.01	20.2	21.4	0.03
Private	22.7	30.2	0.17	26.8	25.4	0.03	30.6	30.2	0.01
Medicare	76.0	12.8	0.41	20.5	20.3	0.01	13.3	12.8	0.02
Medicaid	20.3	14.3	0.16	16.8	18.5	0.05	13.7	14.3	0.02
Self-pay/none	3.8	5.7	0.09	4.7	5.1	0.02	5.8	5.7	0.00
Workers comp	5.5	6.9	0.05	7.7	7.3	0.02	7.3	6.9	0.02
Other	3.6	3.6	0.00	4.1	3.6	0.03	4.7	3.6	0.05
Premorbid conditions									
Alcohol misuse %	39.1	31.7	0.16	33.7	34.3	0.01	32.3	31.7	0.01
Other drug use %	24.8	18.3	0.16	22.3	22.3	0.00	16.7	18.3	0.04
Injury and status at rehabilitation admission									
Cause of injury %									
Fall	38.0	23.6	0.31	29.8	29.0	0.02	23.9	23.6	0.01
Moving vehicle	48.3	65.9	0.36	58.2	60.7	0.05	65.0	65.9	0.02
Violence	8.0	5.4	0.10	7.5	5.7	0.07	6.4	5.4	0.04
Sports/other	5.8	5.1	0.03	4.5	4.5	0.00	4.8	5.1	0.01
Time to rehabilitation (d) Mean ± SD	25.2±30	28.9±34.6	0.11	26.5±33.0	25.5±25.1	0.03	27.3±31.3	28.9±34.6	0.05
FIM Motor at admission (Rasch) Mean ± SD	31.2±16.6	30.2±18.5	0.06	30.7±17.3	29.7±18.2	0.06	29.8±17	30.2±18.5	0.02
FIM Cognitive at admission (Rasch) Mean ± SD	36.8±19.7	34.7±19	0.11	36.2±19.7	34.4±19.0	0.09	33.9±18.8	34.7±19	0.04
Posttraumatic amnesia cleared prior to rehab admission %	37.8	32.8	0.11	36.5	33.5	0.06	30.5	32.8	0.05
Glasgow Coma Score %									
Intubated/missing	52.5	42.0	0.21	45.4	42.4	0.06	40.1	42.0	0.04
Mild	14.8	13.8	0.03	15.2	15.2	0.00	13.9	13.8	0.00
Moderate-severe	32.7	44.2	0.24	39.4	42.4	0.06	46.0	44.2	0.04
Site %									
Site a	12.4	15.5	0.09	15.0	17.6	0.07	14.4	15.5	0.03
Site b	16.6	14.0	0.07	18.1	16.8	0.04	12.5	14.0	0.05
Site c	10.1	4.4	0.22	8.3	7.5	0.03	5.0	4.4	0.03
Site d	7.8	4.1	0.16	6.1	7.1	0.04	4.3	4.1	0.01
Site e	12.6	16.4	0.11	14.6	13.6	0.03	15.0	16.4	0.04
Site f	3.7	8.0	0.18	5.7	6.1	0.02	8.6	8.0	0.02
Site g	15.4	33.5	0.43	24.5	23.9	0.01	36.2	33.5	0.06
Site h	15.5	2.9	0.45	4.3	5.1	0.04	2.9	2.9	0.00
Site i	6.0	1.3	0.25	3.4	2.4	0.06	1.2	1.3	0.01

Abbreviations: MCO/HMO, managed care organization/health maintenance organization.

Table 2 Family involvement model adjusted for unbalanced covariates and theoretically generated covariates, full cohort

Outcome	Time Point (mo)	Sample	N	Average Difference	Lower 95% CI	Upper 95% CI	*P* Value
PART-O Total	3	Matched	890	0.07	0.00	0.15	.06
	9	Matched	847	0.08	−0.01	0.16	.08
	3	Weighted	1609	0.10*	0.03*	0.18*	<.01*
	9	Weighted	1527	0.08	−0.01	0.16	.08
PART-O Total Rasch	3	Matched	810	0.62	−0.57	1.81	.31
	9	Matched	762	0.91	−0.37	2.19	.16
	3	Weighted	1447	1.04	−0.08	2.17	.07
	9	Weighted	1376	0.99	−0.18	2.16	.10
PART-O Out and About	3	Matched	890	0.11*	0.01*	0.21*	.03*
	9	Matched	849	0.15*	0.05*	0.25*	<.01*
	3	Weighted	1611	0.11*	0.01*	0.21*	.03*
	9	Weighted	1531	0.12*	0.02*	0.22*	.02*
PART-O Productivity	3	Matched	893	0.03	−0.07	0.14	.52
	9	Matched	850	0.01	−0.11	0.13	.85
	3	Weighted	1616	0.02	−0.07	0.12	.63
	9	Weighted	1534	0.05	−0.08	0.18	.47
PART-O Social	3	Matched	892	0.08	−0.04	0.20	.18
	9	Matched	847	0.07	−0.05	0.19	.25
	3	Weighted	1612	0.18*	0.06*	0.30*	<.01*
	9	Weighted	1528	0.06	−0.06	0.18	.29
FIM Cognitive (Rasch)	Discharge	Matched	1014	0.07	−1.21	1.36	.91
	3	Matched	853	1.87	−0.46	4.20	.12
	9	Matched	800	2.66*	0.28*	5.03*	.03*
	Discharge	Weighted	1835	0.08	−1.30	1.45	.91
	3	Weighted	1532	0.08	−2.16	2.32	.94
	9	Weighted	1435	2.09	−0.14	4.31	.07
FIM Motor (Rasch)	Discharge	Matched	1014	−0.68	−1.95	0.59	.29
	3	Matched	845	0.79	−1.58	3.15	.51
	9	Matched	793	−0.28	−2.59	2.03	.81
	Discharge	Weighted	1835	−0.07	−1.38	1.24	.91
	3	Weighted	1518	0.04	−2.19	2.28	.97
	9	Weighted	1416	0.09	−2.06	2.25	.93
Satisfaction With Life	3	Matched	678	−0.18	−1.33	0.98	.76
	9	Matched	688	−0.08	−1.33	1.18	.91
	3	Weighted	1206	−0.64	−1.71	0.44	.24
	9	Weighted	1225	−0.32	−1.46	0.82	.58
PHQ-9†	3	Matched	535	0.89	0.61	1.31	.55
	9	Matched	686	1.11	0.77	1.60	.57
	3	Weighted	952	0.94	0.64	1.37	.74
	9	Weighted	1220	1.19	0.84	1.69	.32

NOTE. Adjusted for days injury to rehabilitation admission, FIM Rasch Cognitive, FIM Rasch Motor, age. CSI-brain injury, CSI-nonbrain injury, high school or greater education, previous brain injury, posttraumatic amnesia cleared prior to admission, midline shift status, premorbid impulse control problem, premorbid anxiety, or depressed mood.

* $P<.05$.

† Odds ratio.

Positive effects were identified for FIM Cognitive at 9 months in the matched analysis (average difference: 2.66; 95% CI, 0.28-5.03; $P=.03$) and only slightly attenuated in the IPTW analyses (average difference: 2.09; 95% CI, −0.14 to 4.31; $P=.07$). Findings were slightly attenuated after multiple imputation, but they did not change the inference drawn based on findings.

Stratified analysis based on initial disability

For the Severe TBI subset (n=820), prior to propensity score adjustment, the ASD ranged between 0.00 and 0.49, averaging 0.15, with 60% of the covariates with a ASD>.10. Matched analyses included 207 participants in each group (total n=414). The ASD in the matched groups ranged from 0.00 to 0.13, averaging 0.04, with 10 variables not meeting balance criteria. With IPTW, the ASD ranged from 0.00 to 0.15, averaging 0.04, with 7 variables not meeting balance criteria. Unbalanced covariates were included in the outcome analysis; see table 3 for the full list.

Findings for the Severe subset were similar to those found for the full cohort, but with wider confidence intervals. FI was associated with better PART Out and About scores at 3 and 9 months (in matched analysis: 0.18; 95% CI, 0.02-0.34; $P=.03$ and .21, 95% CI, 0.05-0.36, $P<.01$, respectively, and in IPTW analyses:

Table 3 Family involvement model adjusted for unbalanced covariates, Severe, and Less Severe subgroups

			Severe					Less Severe				
Outcome	Time Point (mo)	Sample	N	Average Difference	Lower 95% CI	Upper 95% CI	*P* Value	N	Average Difference	Lower 95% CI	Upper 95% CI	*P* Value
PART-O Total	3	Matched	374	0.15*	0.02*	0.27*	.02*	427	0.09	−0.02	0.19	.11
	9	Matched	361	0.13	0.00	0.26	.05	397	0.01	−0.12	0.14	.93
	3	Weighted	740	0.11	−0.01	0.22	.08	869	0.07	−0.07	0.21	.32
	9	Weighted	703	0.07	−0.08	0.21	.37	824	0.06	−0.09	0.21	.44
PART-O Total Rasch	3	Matched	339	0.99	−1.16	3.15	.36	383	0.39	−1.21	1.99	.63
	9	Matched	333	1.26	−0.90	3.41	.25	360	−0.08	−1.75	1.60	.93
	3	Weighted	666	1.00	−0.97	2.97	.32	781	0.74	−1.02	2.50	.41
	9	Weighted	642	1.17	−0.81	3.15	.25	748	0.82	−1.00	2.64	.38
PART-O Out and About	3	Matched	374	0.18*	0.02*	0.34*	.03*	427	0.10	−0.05	0.26	.17
	9	Matched	362	0.21*	0.05*	0.36*	<.01*	399	0.04	−0.11	0.20	.57
	3	Weighted	740	0.13	−0.03	0.29	.10	871	0.10	−0.04	0.24	.16
	9	Weighted	705	0.16	−0.01	0.34	.07	826	0.09	−0.08	0.25	.31
PART-O Productivity	3	Matched	375	0.00	−0.13	0.14	.95	430	0.05	−0.10	0.20	.52
	9	Matched	362	0.07	−0.12	0.26	.47	399	−0.05	−0.24	0.14	.61
	3	Weighted	741	−0.04	−0.19	0.11	.62	875	0.01	−0.21	0.24	.91
	9	Weighted	707	−0.04	−0.24	0.17	.73	827	0.03	−0.18	0.23	.81
PART-O Social	3	Matched	375	0.25*	0.06*	0.44*	<.01*	429	0.10	−0.07	0.27	.25
	9	Matched	361	0.14	−0.04	0.31	.13	397	0.02	−0.16	0.21	.80
	3	Weighted	741	0.22*	0.05*	0.39*	<.01*	871	0.10	−0.09	0.28	.31
	9	Weighted	704	0.09	−0.10	0.28	.34	824	0.07	−0.12	0.25	.49
FIM Cognitive Rasch	Discharge	Matched	414	1.30	−1.10	3.70	.29	494	0.28	−1.85	2.41	.80
	3	Matched	347	1.72	−2.37	5.82	.41	409	−0.72	−3.97	2.52	.66
	9	Matched	341	4.36*	0.40*	8.32*	.03*	378	1.46	−1.86	4.79	.39
	Discharge	Weighted	820	0.07	−2.04	2.18	.95	1015	−0.12	−2.52	2.29	.92
	3	Weighted	696	1.11	−2.57	4.79	.56	836	−1.84	−5.07	1.39	.26
	9	Weighted	658	2.66	−0.91	6.24	.14	777	1.34	−1.75	4.44	.39
FIM Motor Rasch	Discharge	Matched	414	−0.03	−2.37	2.30	.98	494	−0.10	−1.96	1.75	.91
	3	Matched	343	0.56	−3.69	4.80	.80	408	1.36	−1.81	4.52	.40
	9	Matched	341	−0.54	−4.82	3.75	.81	373	1.31	−1.70	4.31	.39
	Discharge	Weighted	820	0.05	−2.01	2.11	.96	1015	−0.43	−1.75	0.89	.52
	3	Weighted	688	−0.44	−4.24	3.37	.82	830	−0.70	−3.81	2.41	.66
	9	Weighted	650	−0.18	−4.03	3.67	.93	766	0.53	−2.34	3.41	.72
SWLS	3	Matched	261	−0.60	−2.49	1.29	.53	369	0.62	−0.93	2.18	.43
	9	Matched	265	−0.14	−2.16	1.87	.89	351	0.24	−1.58	2.06	.80
	3	Weighted	475	−0.48	−2.21	1.25	.59	731	−0.15	−1.78	1.48	.86
	9	Weighted	506	0.45	−1.34	2.25	.62	719	−0.80	−2.44	0.83	.34
PHQ-9†	3	Matched	207	1.10	0.60	2.03	.75	295	1.31	0.80	2.13	.29
	9	Matched	265	1.06	0.58	1.95	.84	350	1.45	0.89	2.35	.14
	3	Weighted	366	0.87	0.47	1.62	.66	586	1.11	0.67	1.84	.68
	9	Weighted	503	1.69*	1.01*	2.85*	<.05*	717	1.29	0.80	2.08	.29

NOTE. Adjustment for matched models: days from injury to rehabilitation admission, admission CSI-nonbrain injury, race (Asian or other/unknown), Medicaid payor, Glasgow Coma Scale intubated or missing, computerized tomography: open head injury with contusion or hemorrhage, site (A, G, H); midline shift status. Adjustment for weighted models: sex male; days from injury to rehabilitation admission, admission CSI-nonbrain injury, FIM Rasch Motor; facial fracture; skull fracture; midline shift status; payor (managed care or health maintenance organization), computerized tomography: open versus closed, contusion or hemorrhage versus no contusion or hemorrhage; intraventricular hemorrhage; premorbid impulse control problem.

* Significant.

† Odds ratio.

0.13; 95% CI, −0.03 to 0.29; $P=.10$ and .16; 95% CI, −0.01 to 0.34, $P=.07$), better PART-O Social at 3 months (in matched analyses: average differences 0.25; 95% CI, 0.06-0.44; $P<.01$ and in IPTW analysis: 0.22; 95% CI, 0.05-0.39; $P<.01$), PART-O Total at 3 months (in matched analysis: 0.14; 95% CI, 0.02-0.27; $P=.02$ and in IPTW: .11; 95% CI, −0.01 to 0.22; $P=.08$). In matched analyses, FI suggested a 0.13 point increase on average in PART-O at 9 months (95% CI, 0.00-0.26; $P=.05$); this estimate was smaller in magnitude and higher in variability (average difference: 0.07; 95% CI, −0.08 to 0.21; $P=.37$) in the IPTW analysis. Paradoxically, FI was associated with an increased odds of major depressive disorder symptoms as measured by the PHQ-9 at 9 months for the IPTW analysis only (odds ratio: 1.69; 95% CI, 1.01-2.85; $P<.05$).

The Less Severe subset (n = 1021) initially had ASD for covariates ranging from 0.00 to 0.56, averaging 0.17. Two variance ratios were outside of the acceptable range. Matched analyses included 247 participants in each group (total n = 494). Propensity score matching resulted in 3 covariates with ASD>.10, with the maximum of 0.13 and the average equaling 0.04. The variance ratio for days from injury to rehabilitation was outside of the acceptable range. IPTW was less successful with achieving balance, with 7 variables having ASD>.10 (mean across all variables: 0.04, maximum: 0.19). Three variables had variance ratios outside of the acceptable range. The full list of covariates used to adjust the models is shown in table 3. None of the outcomes of the Less Severe subset showed significant differences attributable to FI.

To determine if FI had different effects for participants with greater and less severe disability at admission to rehabilitation, the point estimates and confidence intervals of the effects were compared across groups. All of the confidence intervals overlapped, often very substantially, indicating that there was little evidence of heterogeneity of treatment based on severity of disability.

Additional sensitivity analyses

Because the use of matching with the full cohort excluded a substantial number of older subjects, exploratory analyses were conducted with participants aged 65 and older. Given the small sample (n = 381), a limited number of covariates (18) were included in the propensity score model. Prior to propensity score adjustment, 67% variables (12/18) had ASD>.10. Matching reduced the number of unbalanced variables to 3 (driving status, craniectomy/craniotomy, premorbid history of difficulties with activities of daily living). After weighting, 3 different variables had ASD>.10 and were included in the outcome analysis (age, admission FIM Cognitive, one of the sites). The findings using these 2 analysis methods were similar to those for the full cohort and the Severe subgroup (see supplemental table S1), with PART-O Out and About, Social, and Total scores showing positive effects with increased FI by both propensity score methods. In weighted analyses, the estimated effect of FI on PHQ-9 suggested an increased odds of depressive symptoms with increased FI (odds ratio: 2.46; 95% CI, 0.89-6.81; $P = .08$). Overall, effects were often larger for the older participants subgroup than observed for the full cohort; however, all confidence intervals overlapped.

Discussion

The hypothesis that FI in rehabilitation is associated with better outcomes was generally supported. Using both analysis methods, participants whose families attended therapy at least 10% of the time were more active in their communities after discharge. Though not always meeting the threshold for traditional statistical significance, findings also suggested that FI could lead to fewer cognitive limitations at 9 months. The severity-stratified analysis showed comparable findings for the Severe subgroup, but the findings for Less Severe subgroup were not as strong. Findings for older participants were similar to those found for the full cohort, suggesting that FI is just as important for older participants as for younger ones, even though it is possibly harder to achieve.

Although the effects on long-term outcomes were small and relatively narrow in scope, it is remarkable that FI in inpatient rehabilitation potentially influences outcomes up to 9 months later. To our knowledge, there has been no direct study of if and how FI in inpatient rehabilitation for adults can positively effect rehabilitation outcomes. Nevertheless, family education has become a standard of care in rehabilitation. Presumably, families who have attended therapy and received education about their loved one's needs will be better prepared for the transition to home and be able to appropriately support continued recovery. The results of the current study support the presumption that FI in the rehabilitation process can continue to influence outcomes long after the initial transition period. However, at this point theorizing about possible mechanisms underlying the influence of FI is largely speculative. One possibility with indirect support in the literature is that the family helps the patient engage in rehabilitation by supporting a strong therapeutic alliance[6] and/or through encouraging practice outside of the formal treatment sessions.[33] Another possible mechanism is that by attending therapy, family members acquire a better understanding of, and learn to accommodate, long-term cognitive and behavioral changes associated with TBI.[2] Findings from a study related to the current study suggest a third possibility: family member attendance in therapy could help to ensure that the activities and tasks used in therapy are those that resemble activities that will actually be done when the patient returns home (*contextualized treatment*). The assumption is: the more time spent in therapy engaged in real-life activities, the better the outcomes.[1] Last, family observation and participation in therapy could have an effect on therapist behavior that, in turn, influences therapy effectiveness.

An alternative explanation of the findings does not presume a causal relation between FI and outcomes, but rather only an association. Although the analytic methods used in the current study facilitate causal inference, all underlying assumptions must be met, including control of all confounders. For the full cohort, we were able to achieve excellent control of all measured confounders; however, it is not known whether all confounders were measured. Unmeasured factors like premorbid family functioning or social support could have confounded the results through a direct relation with both family involvement in rehabilitation and the outcomes under study. The literature indicates inconsistent relations between factors like social support and the outcomes of adults with TBI.[34-36] To our knowledge, no study has established that family functioning or social support affects family attendance in treatment, but such a relation might be anticipated. Only limited family factors were controlled in the current study (eg, with whom the patient lived, marital status, residential status); premorbid family functioning was not measured.

In addition to evaluating the research question, the current study demonstrates some of the pros and cons of different propensity score methods. One-to-one matching is intuitively easier to understand as a simulated randomized controlled trial than IPTW. Although matching may exclude a larger number of participants from analysis, matching with close caliper distance will only include participants who are likely to receive the exposure or treatment of interest (here, FI). Weighting may produce large weights for participants highly unlikely to receive treatment, and often a choice is made to include these participants or to trim extreme weights.[31] For example, the inconsistent result from weighted (but not the matched) subgroup analyses that indicate FI is associated with more depressive symptoms may have been due to heavy weighting of individuals who were highly unlikely to have FI.

Study limitations

The current study based causal inference on propensity score-based estimates from observational study data, rather than on estimates from a more widely accepted randomized controlled trial. One of the assumptions of causal inference in such a case is that all confounders are measured and controlled; however, one can never be certain that this assumption is met. Second, although attrition can affect generalizability, the rate of attrition in the current study was minimal and no substantial differences were observed between analyses using imputations versus complete data, indicating that attrition had minimal effect.

Conclusions

Using propensity score methodology, we found multiple indications that FI makes for better outcomes of TBI rehabilitation. Although we cannot know for certain that family involvement caused better participation during the year after injury, the current study supports efforts to increase family engagement in the rehabilitation process. Other authors have provided suggestions on how to optimally engage family members, such as supporting hope and optimism, encouraging early involvement, and providing education and skills training.[2,36] For families struggling to balance involvement in rehabilitation with other responsibilities, the current study offers reassurance that effective involvement can be as little as attending a couple of hours of treatment a week.

Suppliers

a. SAS, version 9.3; SAS Institute, Inc.
b. Stata, version 14.0; StataCorp.

Keywords

Brain injuries, traumatic; Occupational therapy; Physical therapists; Propensity score; Recreation therapy; Rehabilitation; Speech therapy

Corresponding author

Jennifer Bogner, PhD, FACRM, The Ohio State University College of Medicine, 480 Medical Center Drive, Columbus, OH 43210. *E-mail address:* bogner.1@osu.edu.

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