

## ACCEPTED MANUSCRIPT

Family involvement

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

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This is the author's manuscript of the article published in final edited form as:

Bogner, J., Hade, E. M., Peng, J., Beaulieu, C. L., Horn, S. D., Corrigan, J. D., ... Timpson, M. (2019). Family Involvement in Traumatic Brain Injury Inpatient Rehabilitation: A Propensity Score Analysis of Effects on Outcomes During the First Year After Discharge. *Archives of Physical Medicine and Rehabilitation*. <https://doi.org/10.1016/j.apmr.2019.04.008>

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Presentations: Some of the information in this paper has been presented at meetings of the American Congress of Rehabilitation Medicine (2016), the Federal TBI Interagency Conference (2018), and via webinars sponsored by the Brain Injury Association of America.

Financial support: Research reported in this work was funded through Patient-Centered Outcomes Research Institute® (PCORI®) Award CER-1403-13476. The statements presented in this work are solely the responsibility of the author(s) and do not necessarily represent the views of PCORI, its Board of Governors, or Methodology Committee. Funding for the databases used in this study came from the National Institutes of Health, National Center for Medical Rehabilitation Research (grant 1R01HD050439-01), the National Institute on Disability, Independent Living and Rehabilitation Research (grant H133A080023), and the Ontario Neurotrauma Foundation (grant 2007-ABI-ISIS-525).

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Acknowledgements: This work greatly benefited from the contributions of the stakeholders on the Research Team, including: Carolyn Rocchio, Marvel Vena, Candace Gustafson, Michelle Maust, and Irene Ziaya.

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3 **During the First Year after Discharge**

4

5

**Abstract**

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

8 **Design:** Propensity score methods are applied to the TBI-Practice-Based Evidence (TBI-PBE) database, a database consisting of  
9 multi-site, prospective, longitudinal, observational data.

10 **Setting:** 9 inpatient rehabilitation centers in the US.

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

12 **Intervention:** Family attendance during therapy sessions.

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

16 **Results:** Participants whose families were in attendance for at least 10% of the treatment time were more out and about in their  
17 communities at 3 and 9 months post-discharge than participants whose families attended treatment less than 10% of the time. While

18 findings varied by propensity score method, improved functional independence in the cognitive area at 9 months was also associated  
19 with increased family attendance.

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

23  
24 **Key words**

25 Brain injuries, traumatic; Rehabilitation; Outcome assessment (health care); Physical therapy; Occupational therapy; Speech therapy;  
26 Recreation therapy; Rehabilitation psychology; Propensity score

27  
28 **Abbreviations:**

29  
30 ATT           Average treatment effect on the treated  
31 CSI           Comprehensive Severity Index  
32 FI             Family involvement  
33 FIM           Functional Independence Measure  
34 IPW           Inverse probability weighting

35	PART-O	Participation Assessment with Recombined Tools-Objective
36	PHQ-9	Patient Health Questionnaire-9
37	POC	Point of care
38	PSM	Propensity score methodology
39	RCT	Randomized controlled trial
40	STD	Standardized difference
41	SDC	Supplemental digital content
42	SWLS	Satisfaction with Life Scale
43	TBI	Traumatic brain injury
44	TBI-PBE	Traumatic brain injury Practice Based Evidence study

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

57  
58 An estimate of the effects of family involvement on the rehabilitation outcomes of the patient would assist with decision-making in  
59 regard to family attendance in therapy. Most of the currently available evidence is indirect at best. For example, in the pediatric  
60 rehabilitation literature, parent training has been found to have a positive influence on the child's outcomes.<sup>4</sup> In the adult literature,  
61 studies of post-acute outpatient rehabilitation suggest that family involvement in rehabilitation can have an impact on the therapeutic  
62 alliance, indirectly impacting outcome.<sup>6</sup> Family engagement in post-acute rehabilitation has also been found to be associated with  
63 greater optimism and better emotional health of family members.<sup>7</sup> These latter findings have driven the development of interventions  
64 to assist with family adjustment.<sup>8</sup>

65

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

72

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

78

## 79 **METHODS**

80 The TBI-PBE multi-center dataset was compiled from 2008-2011 to include a wide array of patient characteristics, details of  
81 rehabilitation interventions and medical course, and outcomes.<sup>10</sup> Data were abstracted from medical records and from POC forms



82 completed by therapists after each rehabilitation session. The Institutional Review Board at each center approved the study; each  
83 patient or their proxy gave informed consent.

84

85 *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  
86 for which they were receiving their first exposure to inpatient care on the designated brain injury unit of one of the participating  
87 rehabilitation facilities. For the purposes of the current study, they must have received treatment at one of the 9 US sites (the Canadian  
88 site was excluded from this analysis due to substantive differences in its rehabilitation program). Since the first 3 days of  
89 rehabilitation are used to complete the baseline assessments<sup>11</sup> that yielded confounders in the current study, participants were required  
90 to have a LOS of at least 4 days to be included in the analysis (See Participant Flow Diagram in Supplemental Digital Content [SDC]).

91

92 *Family involvement (FI) in rehabilitation.* Data on family attendance were obtained from the POC forms. FI was operationalized as  
93 attendance by any family member or friend during at least 10% of all treatment minutes provided by occupational, physical, speech, or  
94 recreational therapists, or by psychologists (see SDC Methodology Details for additional details regarding calculation). The cutoff of  
95 10% was determined by evaluating the distribution of percent of session time across all disciplines and days of the stay family  
96 attended, which was found to be highly skewed but best characterized as a dichotomy between those with none or minimal family  
97 involvement versus patients with “substantive” ( $\geq 10\%$ ) family involvement.

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

108  
109 *Potential confounders and prognostically important variables.* Data collection, described in detail in previous publications,<sup>10</sup> also  
110 involved abstraction from medical records by personnel trained to criterion. Only variables that were unlikely to be influenced by FI in  
111 rehabilitation were considered as potential confounders or prognostically important variables, and therefore only those that were  
112 measured prior to or at rehabilitation admission (first 3 days<sup>13</sup>) were included in the propensity score model. The Comprehensive  
113 Severity Index (CSI)-Brain Injury was used to reflect severity of brain-related conditions, while the CSI-Non-Brain Injury score

114 reflected severity of all other medical conditions.<sup>10,30</sup> The full list of potential confounders can be found in SDC, Balance  
115 Diagnostics.

116

### 117 **Data Analyses**

118 Data were analyzed using SAS v9.3 and Stata version 14.0. Propensity score matching and inverse probability treatment weighting  
119 (IPTW) by the estimated propensity score were used to control confounders. The propensity score ( $e$ ), the probability of FI  $\geq 10\%$   
120 conditional on baseline covariates, was estimated through a logistic regression model. Nearest neighbor 1:1 without replacement  
121 matching by the propensity score within a predetermined caliper width (of .01) helped to ensure the two FI groups contained  
122 participants with similar covariate values. Since 1:1 matching excludes some non-exposed, and potentially exposed, participants, we  
123 also used IPTW by the odds and compared the point and variance estimates obtained through matching. Both the matching and the  
124 weighting methods estimated the average treatment effect on the treated (ATT).<sup>31</sup> Adequacy of balance between FI groups for each  
125 potential confounder was assessed using multiple diagnostics.<sup>31,32</sup> For continuous and categorical covariates, the absolute  
126 standardized differences (ASD, the difference in means between groups divided by the pooled standard deviation) were compared  
127 before and after matching or IPTW. Additionally, for continuous covariates, variance ratios and graphical evaluation of covariate  
128 distributions were appraised. Standardized differences below 0.10, and variance ratios between 0.80 and 1.20 were considered to be in  
129 our target balance diagnostic ranges. Multiple propensity score models were considered, including exploration of interaction and  
130 higher order terms, until the best possible balance was achieved.

131

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

138

139 Multiple imputation (40 iterations), by chained equations with predictive mean matching or K-nearest neighbors, of missing outcome  
140 data tested the extent to which missing outcomes might impact inferential findings. Heterogeneity of treatment effect was evaluated by  
141 stratifying the sample into two subgroups: Severe and Less Severe TBI. The Severe subgroup was defined as patients who were  
142 admitted with FIM Motor scores  $< 28.75$  and FIM Cognitive scores at admission  $\leq 15$ ,  $n=820$  (Case Mix Groups (CMG) levels 206  
143 or 207). The Less Severe subgroup consisted of the remainder of the sample ( $n=1015$ ).

144

## 145 **RESULTS**

146 1843 participants provided at least one outcome data point (see SDC Figure 1 for flow diagram), with 905 receiving  $FI \geq 10\%$ , and 938  
147 receiving  $FI < 10\%$ . Only 1835 participants were used in the outcome analysis due to 8 participants missing covariate data. As shown

148 in Table 1 and SDC Balance Diagnostics, patients who received FI  $\geq 10\%$  were more likely to be younger, white, not insured by  
149 Medicare, and injured in a moving vehicle accident (and not a fall). Some site differences were also observed. Prior to matching or  
150 weighting, substantial imbalance was observed: a) the ASD of the confounders ranged from .00-.53 (average .15), with 59% (53/90) of  
151 the confounders having ASD  $> .10$ ; b) variance ratios ranged from .68 to 1.33, with three variables being outside the criterion range.

152

153 *Full cohort analysis.* Close matches, within our caliper distance, were not found for 821 participants and therefore they were not  
154 included in the matched analysis. Those not included in the matched analyses tended to be older, not driving, previously married,  
155 retired, and had a higher FIM Motor Score at admission (all  $p < .05$ ). IPTW allowed use of the full sample. The balance diagnostics  
156 after using each propensity score method were excellent: a) ASDs with matching ranged from .00-.09 (average .03); b) ASDs using  
157 IPTW ranged from 0.00-0.10 (averaging .03); c) for both methods, only the variance ratio for days from injury to rehabilitation  
158 admission fell outside of the criterion window; d) for both methods, the distributions of the continuous variables were comparable (see  
159 SDC, Balance Diagnostics) and the area of common support was excellent.

160

161 Regression models for matched and IPTW analyses estimated the effect of FI, adjusted for days from injury to rehabilitation  
162 admission, and the additional theoretically influential variables. As shown in Table 2, consistent positive and significant ( $p < .05$ )  
163 findings by both propensity score methods were identified for PART-O Out and About at 3 and 9 months. FI  $\geq 10\%$  was associated  
164 with an increase in PART-O Out and About at 3 months of 0.11 points (95% CI: 0.01, 0.21, by both methods) and between 0.12

165 (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  
166 month scores also suggested positive effects with increased FI, however PART-O Total effect sizes are generally smaller than Out and  
167 About (ranging between 0.07 and 0.10 points) and the p-values ranged from .01 to .16 (with one p-value=0.31). Positive effects were  
168 identified for FIM Cognitive at 9 months in the matched analysis (average difference: 2.66, 95% CI: 0.28, 5.03, p=0.03) and only  
169 slightly attenuated in the IPTW analyses (average difference: 2.09, 95% CI: -0.14, 4.31, p=0.07). Findings were slightly attenuated  
170 after multiple imputation, but they did not change the inference drawn based on findings.

171

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

177

178 Findings for the Severe subset were similar to those found for the full cohort, but with wider confidence intervals. FI was associated  
179 with better PART Out and About scores at 3 and 9 months (in matched analysis: 0.18, 95% CI: 0.02, 0.34, p=0.03 and 0.21, 95% CI:  
180 0.05, 0.36, p<0.01 respectively, and in IPTW analyses: 0.13, 95% CI: -0.03, 0.29, p=0.10 and 0.16, 95% CI: -0.01, 0.34, p=0.07),  
181 better PART-O Social at 3 months (in matched analyses: average differences 0.25, 95% CI: 0.06, 0.44, p<0.01 and in IPTW analysis:

182 0.22, 95% CI: 0.05, 0.39,  $p < 0.01$ ), PART-O Total at 3-months (in matched analysis: 0.14, 95% CI: 0.02, 0.27,  $p = 0.02$  and in IPTW:  
183 .11, 95% CI: -0.01, 0.22,  $p = 0.08$ ). In matched analyses, FI suggested a 0.13 point increase on average in PART-O at 9 months (95%  
184 CI: 0.00, 0.26,  $p = 0.05$ ); this estimate was smaller in magnitude and higher in variability (average difference: 0.07, 95% CI: -0.08-,  
185 0.21,  $p = 0.37$ ) in the IPTW analysis. Paradoxically, FI was associated with an increased odds of major depressive disorder symptoms  
186 as measured by the PHQ-9 at 9 months, for the IPTW analysis only (OR: 1.69, 95% CI: 1.01, 2.85,  $p < .05$ ).

187

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

195

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

199

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

210

## 211 **DISCUSSION**

212 The hypothesis that FI in rehabilitation is associated with better outcomes was generally supported. Using both analysis methods,  
213 participants whose families attended therapy at least 10% of the time were more active in their communities after discharge. Though  
214 not always meeting the threshold for traditional statistical significance, findings also suggested that FI could lead to fewer cognitive  
215 limitations at 9 months. The severity-stratified analysis showed comparable findings for the Severe subgroup, but the findings for



216 Less Severe subgroup were not as strong. Findings for older participants were similar to those found for the full cohort, suggesting  
217 that FI is just as important for older participants as for younger ones, even though it is possibly harder to achieve.

218

219 While the effects on long-term outcomes were small and relatively narrow in scope, it is remarkable that FI in inpatient rehabilitation  
220 potentially influences outcomes up to 9 months later. To our knowledge, there has been no direct study of if and how FI in inpatient  
221 rehabilitation for adults can positively impact rehabilitation outcomes. Nevertheless, family education has become a standard of care  
222 in rehabilitation. Presumably, families who have attended therapy and received education about their loved one's needs will be better  
223 prepared for the transition to home and be able to appropriately support continued recovery. The results of the current study support  
224 the presumption that FI in the rehabilitation process can continue to influence outcomes long after the initial transition period.

225 However, at this point theorizing about possible mechanisms underlying the influence of FI is largely speculative. One possibility  
226 with indirect support in the literature is that the family helps the patient engage in rehabilitation by supporting a strong therapeutic  
227 alliance<sup>6</sup> and/or through encouraging practice outside of the formal treatment sessions.<sup>33</sup> Another possible mechanism is that by  
228 attending therapy, family members acquire a better understanding of, and learn to accommodate, long-term cognitive and behavioral  
229 changes associated with TBI.<sup>2</sup> Findings from a study related to the current study suggest a third possibility: family member  
230 attendance in therapy could help to ensure that the activities and tasks used in therapy are those that resemble activities that will  
231 actually be done when the patient returns home ( 'contextualized treatment'). The assumption is: the more time spent in therapy

232 engaged in real-life activities, the better the outcomes.<sup>1</sup> Lastly, family observation and participation in therapy could have an impact  
233 on therapist behavior that, in turn, influences therapy effectiveness.

234

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

244

245 In addition to evaluating the research question, the current study demonstrates some of the pros and cons of different propensity score  
246 methods. 1:1 matching is intuitively easier to understand as a simulated randomized controlled trial (RCT) than IPTW. While  
247 matching may exclude a larger number of participants from analysis, matching with close caliper distance will only include  
248 participants who are likely to receive the exposure/treatment of interest (here, FI). Weighting may produce large weights for

249 participants highly unlikely to receive treatment, and often a choice is made to include these participants or to trim extreme weights.<sup>31</sup>  
250 For example, the inconsistent result from weighted (but not the matched) subgroup analyses that indicate FI is associated with more  
251 depressive symptoms may have been due to heavy weighting of individuals who were highly unlikely to have FI.

## 252 **Study limitations**

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

258

## 259 **Conclusions**

260 Using propensity score methodology, we found multiple indications that FI makes for better outcomes of TBI rehabilitation. While we  
261 cannot know for certain that family involvement caused better participation during the year after injury, the current study supports  
262 efforts to increase family engagement in the rehabilitation process. Other authors have provided suggestions on how to optimally  
263 engage family members, such as supporting hope and optimism, encouraging early involvement, and providing education and skills

264 training.<sup>2,36</sup> For families struggling to balance involvement in rehabilitation with other responsibilities, the current study offers  
265 reassurance that effective involvement can be as little as attending a couple of hours of treatment a week.

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Table 1: Demographic and clinical characteristics of full cohort at admission, by FI, prior to and with Matching and Weighting

	Before PSM			Matched			Weighted		
	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
<b>Demographics</b>									
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 gender %	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
<b>Premorbid Conditions</b>									

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
<b>Injury and status at rehabilitation admission</b>									
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 (days) 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
Post traumatic 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 %	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

PSM=propensity score method; ASD=absolute standardized difference; FI=Family involvement; rehab=rehabilitation.

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

Outcome	Time Point	Sample	N	Average Difference	Lower 95% CI	Upper 95% CI	p-value
PART-O Total	3-Month	Matched	890	0.07	0.00	0.15	0.06
	9-Month	Matched	847	0.08	-0.01	0.16	0.08
	3-Month	Weighted	1609	<b>0.10</b>	<b>0.03</b>	<b>0.18</b>	<b>&lt;0.01</b>
	9-Month	Weighted	1527	0.08	-0.01	0.16	0.08
PART-O Total Rasch	3-Month	Matched	810	0.62	-0.57	1.81	0.31
	9-Month	Matched	762	0.91	-0.37	2.19	0.16
	3-Month	Weighted	1447	1.04	-0.08	2.17	0.07
	9-Month	Weighted	1376	0.99	-0.18	2.16	0.10
PART-O Out and About	3-Month	Matched	890	<b>0.11</b>	<b>0.01</b>	<b>0.21</b>	<b>0.03</b>
	9-Month	Matched	849	<b>0.15</b>	<b>0.05</b>	<b>0.25</b>	<b>&lt;0.01</b>
	3-Month	Weighted	1611	<b>0.11</b>	<b>0.01</b>	<b>0.21</b>	<b>0.03</b>
	9-Month	Weighted	1531	<b>0.12</b>	<b>0.02</b>	<b>0.22</b>	<b>0.02</b>
PART-O Productivity	3-Month	Matched	893	0.03	-0.07	0.14	0.52
	9-Month	Matched	850	0.01	-0.11	0.13	0.85
	3-Month	Weighted	1616	0.02	-0.07	0.12	0.63
	9-Month	Weighted	1534	0.05	-0.08	0.18	0.47
PART-O Social	3-Month	Matched	892	0.08	-0.04	0.20	0.18
	9-Month	Matched	847	0.07	-0.05	0.19	0.25
	3-Month	Weighted	1612	<b>0.18</b>	<b>0.06</b>	<b>0.30</b>	<b>&lt;0.01</b>
	9-Month	Weighted	1528	0.06	-0.06	0.18	0.29
FIM Cognitive (Rasch)	Discharge	Matched	1014	0.07	-1.21	1.36	0.91
	3-Month	Matched	853	1.87	-0.46	4.20	0.12
	9-Month	Matched	800	<b>2.66</b>	<b>0.28</b>	<b>5.03</b>	<b>0.03</b>
	Discharge	Weighted	1835	0.08	-1.30	1.45	0.91
	3-Month	Weighted	1532	0.08	-2.16	2.32	0.94
	9-Month	Weighted	1435	2.09	-0.14	4.31	0.07
FIM Motor (Rasch)	Discharge	Matched	1014	-0.68	-1.95	0.59	0.29
	3-Month	Matched	845	0.79	-1.58	3.15	0.51
	9-Month	Matched	793	-0.28	-2.59	2.03	0.81
	Discharge	Weighted	1835	-0.07	-1.38	1.24	0.91

	3-Month	Weighted	1518	0.04	-2.19	2.28	0.97
	9-Month	Weighted	1416	0.09	-2.06	2.25	0.93
Satisfaction With Life	3-Month	Matched	678	-0.18	-1.33	0.98	0.76
	9-Month	Matched	688	-0.08	-1.33	1.18	0.91
	3-Month	Weighted	1206	-0.64	-1.71	0.44	0.24
	9-Month	Weighted	1225	-0.32	-1.46	0.82	0.58
PHQ-9*	3-Month	Matched	535	0.89	0.61	1.31	0.55
	9-Month	Matched	686	1.11	0.77	1.60	0.57
	3-Month	Weighted	952	0.94	0.64	1.37	0.74
	9-Month	Weighted	1220	1.19	0.84	1.69	0.32

\*Odds ratio; Bold= $p < .05$ ; Adjusted for: Days injury to rehabilitation admission, FIM Rasch Cognitive, FIM Rasch Motor, age, Comprehensive Severity Index Brain Injury, Comprehensive Severity Index Non-Brain Injury, high school or greater education, previous brain injury, post-traumatic amnesia cleared prior to admission, midline shift status, premorbid impulse control problem, premorbid anxiety or depressed mood.

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

Outcome	Time Point	Sample	N	Severe				Less Severe				
				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-Month	Matched	374	<b>0.14</b>	<b>0.02</b>	<b>0.27</b>	<b>0.02</b>	427	0.09	-0.02	0.19	0.11
	9-Month	Matched	361	0.13	0.00	0.26	0.05	397	0.01	-0.12	0.14	0.93
	3-Month	Weighted	740	0.11	-0.01	0.22	0.08	869	0.07	-0.07	0.21	0.32
	9-Month	Weighted	703	0.07	-0.08	0.21	0.37	824	0.06	-0.09	0.21	0.44
PART-O Total Rasch	3-Month	Matched	339	0.99	-1.16	3.15	0.36	383	0.39	-1.21	1.99	0.63
	9-Month	Matched	333	1.26	-0.90	3.41	0.25	360	-0.08	-1.75	1.60	0.93
	3-Month	Weighted	666	1.00	-0.97	2.97	0.32	781	0.74	-1.02	2.50	0.41
	9-Month	Weighted	642	1.17	-0.81	3.15	0.25	748	0.82	-1.00	2.64	0.38
PART-O Out and About	3-Month	Matched	374	<b>0.18</b>	<b>0.02</b>	<b>0.34</b>	<b>0.03</b>	427	0.10	-0.05	0.26	0.17
	9-Month	Matched	362	<b>0.21</b>	<b>0.05</b>	<b>0.36</b>	<b>&lt;0.01</b>	399	0.04	-0.11	0.20	0.57
	3-Month	Weighted	740	0.13	-0.03	0.29	0.10	871	0.10	-0.04	0.24	0.16
	9-Month	Weighted	705	0.16	-0.01	0.34	0.07	826	0.09	-0.08	0.25	0.31
PART-O Productivity	3-Month	Matched	375	0.00	-0.13	0.14	0.95	430	0.05	-0.10	0.20	0.52
	9-Month	Matched	362	0.07	-0.12	0.26	0.47	399	-0.05	-0.24	0.14	0.61
	3-Month	Weighted	741	-0.04	-0.19	0.11	0.62	875	0.01	-0.21	0.24	0.91
	9-Month	Weighted	707	-0.04	-0.24	0.17	0.73	827	0.03	-0.18	0.23	0.81
PART-O Social	3-Month	Matched	375	<b>0.25</b>	<b>0.06</b>	<b>0.44</b>	<b>&lt;0.01</b>	429	0.10	-0.07	0.27	0.25
	9-Month	Matched	361	0.14	-0.04	0.31	0.13	397	0.02	-0.16	0.21	0.80

	3-Month	Weighted	741	<b>0.22</b>	<b>0.05</b>	<b>0.39</b>	<b>&lt;0.01</b>	871	0.10	-0.09	0.28	0.31
	9-Month	Weighted	704	0.09	-0.10	0.28	0.34	824	0.07	-0.12	0.25	0.49
FIM Cognitive Rasch	Discharge	Matched	414	1.30	-1.10	3.70	0.29	494	0.28	-1.85	2.41	0.80
	3-Month	Matched	347	1.72	-2.37	5.82	0.41	409	-0.72	-3.97	2.52	0.66
	9-Month	Matched	341	<b>4.36</b>	<b>0.40</b>	<b>8.32</b>	<b>0.03</b>	378	1.46	-1.86	4.79	0.39
	Discharge	Weighted	820	0.07	-2.04	2.18	0.95	1015	-0.12	-2.52	2.29	0.92
	3-Month	Weighted	696	1.11	-2.57	4.79	0.56	836	-1.84	-5.07	1.39	0.26
	9-Month	Weighted	658	2.66	-0.91	6.24	0.14	777	1.34	-1.75	4.44	0.39
FIM Motor Rasch	Discharge	Matched	414	-0.03	-2.37	2.30	0.98	494	-0.10	-1.96	1.75	0.91
	3-Month	Matched	343	0.56	-3.69	4.80	0.80	408	1.36	-1.81	4.52	0.40
	9-Month	Matched	341	-0.54	-4.82	3.75	0.81	373	1.31	-1.70	4.31	0.39
	Discharge	Weighted	820	0.05	-2.01	2.11	0.96	1015	-0.43	-1.75	0.89	0.52
	3-Month	Weighted	688	-0.44	-4.24	3.37	0.82	830	-0.70	-3.81	2.41	0.66
	9-Month	Weighted	650	-0.18	-4.03	3.67	0.93	766	0.53	-2.34	3.41	0.72
SWLS	3-Month	Matched	261	-0.60	-2.49	1.29	0.53	369	0.62	-0.93	2.18	0.43
	9-Month	Matched	265	-0.14	-2.16	1.87	0.89	351	0.24	-1.58	2.06	0.80
	3-Month	Weighted	475	-0.48	-2.21	1.25	0.59	731	-0.15	-1.78	1.48	0.86
	9-Month	Weighted	506	0.45	-1.34	2.25	0.62	719	-0.80	-2.44	0.83	0.34
PHQ-9*	3-Month	Matched	207	1.10	0.60	2.03	0.75	295	1.31	0.80	2.13	0.29
	9-Month	Matched	265	1.06	0.58	1.95	0.84	350	1.45	0.89	2.35	0.14
	3-Month	Weighted	366	0.87	0.47	1.62	0.66	586	1.11	0.67	1.84	0.68
	9-Month	Weighted	503	<b>1.69</b>	<b>1.01</b>	<b>2.85</b>	<b>&lt;0.05</b>	717	1.29	0.80	2.08	0.29

\* odds ratio; SWLS=Satisfaction with Life Scale; PHQ-9=Patient Health Questionnaire-9; Bold=significant; Adjustment for matched models: Days from injury to rehabilitation admission, admission Comprehensive Severity Index Non-Brain Injury, race (Asian or



other/unknown), Medicaid payor, GCS intubated or missing, CT: open head injury with contusion or hemorrhage, site (A, G, H); midline shift status. Adjustment for weighted models: Gender male; Days from injury to rehabilitation admission, admission Comprehensive Severity Index Non-Brain Injury, FIM Rasch Motor; facial fracture; skull fracture; midline shift status; payor (managed care or health maintenance organization), CT: open vs. closed, contusion/hemorrhage vs. no contusion hemorrhage; intraventricular hemorrhage; premorbid impulse control problem.

n=1,843	No (n=938)	Yes (n=905)	Standardised Differences	Variance Ratio Yes/No
Age at admission	49.5 (21.8)	39.1 (19.7)	0.501	0.81559
Age squared	2926.2 (2273.5)	1916.9 (1879.4)	0.484	0.68337
Days injury to rehab admission	25.2 (30)	28.9 (34.6)	0.114	1.33467
Admission FIM RASCH Motor	31.2 (16.6)	30.2 (18.5)	0.057	1.23756
Admission FIM RASCH Cognitive	36.8 (19.7)	34.7 (19)	0.111	0.93479
Admission CSI Brain Injury	44.6 (22.6)	49.1 (23.7)	0.195	1.10329
Admission CSI Non-Brain Injury	17.2 (14.9)	18.3 (15)	0.075	1.00868
Agitated Behavior Scale score average 1st 3 day	17.3 (4.3)	17.3 (4.3)	0.006	1.00187
Maximum Pain Score First 3 Days	4.3 (3.9)	4.7 (3.7)	0.088	0.93825
Sex male,	664 (70.8)	660 (72.9)	0.048	.
Marital status single	376 (40.1)	408 (45.1)	0.101	.
Marital status married	292 (31.1)	377 (41.7)	0.22	.
Marital status previously married	231 (24.6)	98 (10.8)	0.367	.
Marital status other	39 (4.2)	22 (2.4)	0.097	.
No prior brain injury	846 (90.2)	843 (93.1)	0.107	.
One prior brain injury	74 (7.9)	44 (4.9)	0.124	.
2+ prior brain injuries	18 (1.9)	18 (2)	0.005	.
Premorbid alcohol misuse	367 (39.1)	287 (31.7)	0.155	.
Premorbid drug use	233 (24.8)	166 (18.3)	0.158	.
High school education	645 (68.8)	688 (76)	0.163	.
Not a driver pre-injury	132 (14.1)	58 (6.4)	0.255	.
Driver pre-injury	579 (61.7)	763 (84.3)	0.526	.
Driving status unknown	227 (24.2)	84 (9.3)	0.408	.
Employed and Student	21 (2.2)	45 (5)	0.147	.
Employed Only,	395 (42.1)	466 (51.5)	0.189	.
Not Employed	147 (15.7)	106 (11.7)	0.115	.
Retired	291 (31)	136 (15)	0.387	.
Student Only	70 (7.5)	145 (16)	0.268	.
Unknown Employment)	14 (1.5)	7 (0.8)	0.068	.
Paralysis	354 (37.7)	360 (39.8)	0.042	.
Lived alone	180 (19.2)	71 (7.8)	0.336	.
Lived with significant other/spouse	327 (34.9)	453 (50.1)	0.311	.
Lived with family	328 (35)	292 (32.3)	0.057	.
Lived with other	103 (11)	89 (9.8)	0.038	.
Race white	654 (69.7)	741 (81.9)	0.287	.
Race white Hispanic	73 (7.8)	41 (4.5)	0.136	.
Race black	183 (19.5)	97 (10.7)	0.247	.
Race Asian, other or unknown	28 (3)	26 (2.9)	0.007	.
Cleared post-traumatic amnesia prior to admission	355 (37.8)	297 (32.8)	0.105	.
Payer: Medicare	275 (29.3)	116 (12.8)	0.413	.
Payer: Medicaid	190 (20.3)	129 (14.3)	0.159	.
Payer: Private	213 (22.7)	273 (30.2)	0.17	.
Payer: Workers Comp	52 (5.5)	62 (6.9)	0.054	.
Payer: Self or None	36 (3.8)	52 (5.7)	0.089	.
Payer: MCO HMO	93 (9.9)	194 (21.4)	0.321	.
Payer: No Fault Auto	45 (4.8)	46 (5.1)	0.013	.
Payer: Other	34 (3.6)	33 (3.6)	0.001	.
Cause of injury: fall	356 (38)	214 (23.6)	0.314	.
Cause of injury: sports or other	54 (5.8)	46 (5.1)	0.03	.
Cause of injury: moving vehicle crash	453 (48.3)	596 (65.9)	0.361	.
Cause of injury: violence	75 (8)	49 (5.4)	0.103	.
GCS: Intubated/Sedated or Missing	492 (52.5)	380 (42)	0.211	.
GCS: Mild	139 (14.8)	125 (13.8)	0.029	.
GCS: Moderate or Severe	307 (32.7)	400 (44.2)	0.237	.
Closed head injury with contusion or hemorrhage	685 (73)	620 (68.5)	0.099	.
Closed head injury without contusion or hemorrhage	178 (19)	226 (25)	0.145	.
Open head injury with contusion or hemorrhage	75 (8)	59 (6.5)	0.057	.
Facial fracture	115 (12.3)	136 (15)	0.081	.
Skull fracture	216 (23)	266 (29.4)	0.145	.
Subdural hematoma	469 (50)	392 (43.3)	0.134	.
Epidural hematoma	64 (6.8)	78 (8.6)	0.067	.
Subarachnoid hemorrhage	521 (55.5)	562 (62.1)	0.134	.
Intraventricular hemorrhage	162 (17.3)	181 (20)	0.07	.
Brain stem involvement	55 (5.9)	49 (5.4)	0.019	.
Premorbid behavioral control disorder	46 (4.9)	61 (6.7)	0.078	.
Premorbid learning disorder	41 (4.4)	47 (5.2)	0.039	.
Weight-bearing precautions 1st 3 days	202 (21.5)	228 (25.2)	0.087	.
Moderate-severe aphasia	485 (51.7)	436 (48.2)	0.071	.
Mild to severe ataxia	128 (13.6)	164 (18.1)	0.123	.
Site a	116 (12.4)	140 (15.5)	0.09	.
Site b	156 (16.6)	127 (14)	0.072	.
Site c	95 (10.1)	40 (4.4)	0.221	.
Site d	73 (7.8)	37 (4.1)	0.157	.

	No (n=938)	Yes (n=905)	Standardised Differences	Variance Ratio Yes/No
Site e	118 (12.6)	148 (16.4)	0.107	.
Site f	35 (3.7)	72 (8)	0.181	.
Site g	144 (15.4)	303 (33.5)	0.432	.
Site h	145 (15.5)	26 (2.9)	0.447	.
Site i	56 (6)	12 (1.3)	0.25	.
Craniotomy	188 (20)	165 (18.2)	0.046	.
Craniectomy	70 (7.5)	60 (6.6)	0.033	.
Premorbid anxiety/depression	211 (22.5)	202 (22.3)	0.004	.
Premorbid chronic pain	152 (16.2)	140 (15.5)	0.02	.
Premorbid adult central nervous system disorder	130 (13.9)	56 (6.2)	0.258	.
Impaired activities of daily living premorbidly	49 (5.2)	28 (3.1)	0.107	.
Midline shift 0-5mm	133 (14.2)	106 (11.7)	0.074	.
Midline shift >5mm	111 (11.8)	100 (11)	0.025	.
Midline shift not otherwise specified	113 (12)	93 (10.3)	0.056	.
No midline shift	299 (31.9)	271 (29.9)	0.042	.
Unknown midline shift	282 (30.1)	335 (37)	0.148	.
Lived at home	899 (95.8)	888 (98.1)	0.134	.

Table 5. Balance Diagnostics for Hypothesis 2.2., Family Involvement: Standardized Differences and Variance Ratios after Matching

ACCEPTED MANUSCRIPT				
n=1,014	No (n=507)	Yes (n=507)	Standardised Differences	Variance Ratio Yes/No
Age at admission	43.5 (21.1)	43.8 (21.3)	0.014	1.01994
Age squared	2333.8 (2102.4)	2368.9 (2127.7)	0.017	1.02418
Days injury to rehab admission	26.5 (33)	25.5 (25.1)	0.034	0.57999
Admission FIM RASCH Motor	30.7 (17.3)	29.7 (18.2)	0.058	1.0977
Admission FIM RASCH Cognitive	36.2 (19.7)	34.4 (19)	0.091	0.92726
Admission CSI Brain Injury	46.2 (23.5)	48.2 (23.3)	0.084	0.98387
Admission CSI Non-Brain Injury	17.8 (15.9)	17.7 (14.5)	0.003	0.83002
Agitated Behavior Scale score average 1st 3 day	17.3 (4.4)	17.5 (4.6)	0.053	1.11999
Maximum Pain Score First 3 Days	4.7 (3.8)	4.6 (3.8)	0.021	0.97737
Sex male,	370 (73)	367 (72.4)	0.013	.
Marital status single	215 (42.4)	211 (41.6)	0.016	.
Marital status married	204 (40.2)	198 (39.1)	0.024	.
Marital status previously married	74 (14.6)	82 (16.2)	0.044	.
Marital status other	14 (2.8)	16 (3.2)	0.023	.
No prior brain injury	470 (92.7)	470 (92.7)	0	.
One prior brain injury	25 (4.9)	29 (5.7)	0.035	.
2+ prior brain injuries	12 (2.4)	8 (1.6)	0.057	.
Premorbid alcohol misuse	171 (33.7)	174 (34.3)	0.012	.
Premorbid drug use	113 (22.3)	113 (22.3)	0	.
High school education	370 (73)	368 (72.6)	0.009	.
Not a driver pre-injury	47 (9.3)	46 (9.1)	0.007	.
Driver pre-injury	390 (76.9)	392 (77.3)	0.009	.
Driving status unknown	70 (13.8)	69 (13.6)	0.006	.
Employed and Student	18 (3.6)	16 (3.2)	0.022	.
Employed Only,	240 (47.3)	241 (47.5)	0.004	.
Not Employed	74 (14.6)	77 (15.2)	0.017	.
Retired	108 (21.3)	109 (21.5)	0.005	.
Student Only	61 (12)	57 (11.2)	0.025	.
Unknown Employment)	6 (1.2)	7 (1.4)	0.018	.
Paralysis	192 (37.9)	191 (37.7)	0.004	.
Lived alone	57 (11.2)	58 (11.4)	0.006	.
Lived with significant other/spouse	235 (46.4)	227 (44.8)	0.032	.
Lived with family	166 (32.7)	169 (33.3)	0.013	.
Lived with other	49 (9.7)	53 (10.5)	0.026	.
Race white	388 (76.5)	391 (77.1)	0.014	.
Race white Hispanic	27 (5.3)	29 (5.7)	0.017	.
Race black	80 (15.8)	73 (14.4)	0.039	.
Race Asian, other or unknown	12 (2.4)	14 (2.8)	0.025	.
Cleared post-traumatic amnesia prior to admission	185 (36.5)	170 (33.5)	0.062	.
Payer: Medicare	104 (20.5)	103 (20.3)	0.005	.
Payer: Medicaid	85 (16.8)	94 (18.5)	0.047	.
Payer: Private	136 (26.8)	129 (25.4)	0.031	.
Payer: Workers Comp	39 (7.7)	37 (7.3)	0.015	.
Payer: Self or None	24 (4.7)	26 (5.1)	0.018	.
Payer: MCO HMO	76 (15)	74 (14.6)	0.011	.
Payer: No Fault Auto	22 (4.3)	26 (5.1)	0.037	.
Payer: Other	21 (4.1)	18 (3.6)	0.031	.
Cause of injury: fall	151 (29.8)	147 (29)	0.017	.
Cause of injury: sports or other	23 (4.5)	23 (4.5)	0	.
Cause of injury: moving vehicle crash	295 (58.2)	308 (60.7)	0.052	.
Cause of injury: violence	38 (7.5)	29 (5.7)	0.072	.
GCS: Intubated/Sedated or Missing	230 (45.4)	215 (42.4)	0.06	.
GCS: Mild	77 (15.2)	77 (15.2)	0	.
GCS: Moderate or Severe	200 (39.4)	215 (42.4)	0.06	.
Closed head injury with contusion or hemorrhage	366 (72.2)	383 (75.5)	0.076	.
Closed head injury without contusion or hemorrhage	104 (20.5)	93 (18.3)	0.055	.
Open head injury with contusion or hemorrhage	37 (7.3)	31 (6.1)	0.047	.
Facial fracture	79 (15.6)	67 (13.2)	0.067	.
Skull fracture	145 (28.6)	144 (28.4)	0.004	.
Subdural hematoma	233 (46)	231 (45.6)	0.008	.
Epidural hematoma	34 (6.7)	45 (8.9)	0.081	.
Subarachnoid hemorrhage	310 (61.1)	314 (61.9)	0.016	.
Intraventricular hemorrhage	98 (19.3)	100 (19.7)	0.01	.
Brain stem involvement	27 (5.3)	29 (5.7)	0.017	.
Premorbid behavioral control disorder	35 (6.9)	26 (5.1)	0.075	.
Premorbid learning disorder	21 (4.1)	20 (3.9)	0.01	.
Weight-bearing precautions 1st 3 days	124 (24.5)	125 (24.7)	0.005	.
Moderate-severe aphasia	244 (48.1)	258 (50.9)	0.055	.
Mild to severe ataxia	83 (16.4)	82 (16.2)	0.005	.
Site a	76 (15)	89 (17.6)	0.07	.
Site b	92 (18.1)	85 (16.8)	0.036	.
Site c	42 (8.3)	38 (7.5)	0.029	.
Site d	31 (6.1)	36 (7.1)	0.04	.
Site e	74 (14.6)	69 (13.6)	0.028	.
Site f	29 (5.7)	31 (6.1)	0.017	.

Table 5. Balance Diagnostics for Hypothesis 2.2., Family Involvement: Standardized Differences and Variance Ratios after Matching

	No (n=507)	Yes (n=507)	Standardised Differences	Variance Ratio Yes/No
Site g	124 (24.5)	121 (23.9)	0.014	.
Site h	22 (4.3)	26 (5.1)	0.037	.
Site i	17 (3.4)	12 (2.4)	0.059	.
Craniotomy	98 (19.3)	90 (17.8)	0.041	.
Craniectomy	31 (6.1)	35 (6.9)	0.032	.
Premorbid anxiety/depression	117 (23.1)	102 (20.1)	0.072	.
Premorbid chronic pain	81 (16)	84 (16.6)	0.016	.
Premorbid adult central nervous system disorder	45 (8.9)	44 (8.7)	0.007	.
Impaired activities of daily living premorbidly	25 (4.9)	23 (4.5)	0.019	.
Midline shift 0-5mm	58 (11.4)	62 (12.2)	0.024	.
Midline shift >5mm	57 (11.2)	56 (11)	0.006	.
Midline shift not otherwise specified	56 (11)	50 (9.9)	0.039	.
No midline shift	160 (31.6)	164 (32.3)	0.017	.
Unknown midline shift	176 (34.7)	175 (34.5)	0.004	.
Lived at home	492 (97)	497 (98)	0.064	.

Table 6. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Percentiles before Matching

	Treatment	N	Min	P10	P25	Median	P75	P90	Max
Agitated Behavior Scal	Total Family Involvement Percent $\geq 10$ : No	938	14	14	14	15.51	18.89	23.59	45.57
Agitated Behavior Scal	Total Family Involvement Percent $\geq 10$ : Yes	905	14	14	14	15.64	18.75	23.24	42
Agitated Behavior Scal	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	14	14	14	15.56	18.85	23.4	45.57
Admission CSI Brain In	Total Family Involvement Percent $\geq 10$ : No	938	0	16	28	42.5	61	77	106
Admission CSI Brain In	Total Family Involvement Percent $\geq 10$ : Yes	905	0	20	30	48	67	81	111
Admission CSI Brain In	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	0	17	29	44	64	79	111
Admission CSI Non-Bra	Total Family Involvement Percent $\geq 10$ : No	938	0	0	8	13	25	37	148
Admission CSI Non-Bra	Total Family Involvement Percent $\geq 10$ : Yes	905	0	4	8	16	26	39	89
Admission CSI Non-Bra	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	0	4	8	13	25	38	148
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : No	938	0	0	28	41	51	57	100
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	24	38	49	56	90
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	0	0	24	38	49	57	100
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : No	938	0	0	22	35	43	49	83
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	16	35	45	51	74
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	0	0	20	35	44	50	83
Age At Admission	Total Family Involvement Percent $\geq 10$ : No	938	14.79	20.487	28.624	48.85	66.94	80.26	99.78
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes	905	14.141	18.448	21.9	33.94	51.95	69.58	97.79
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	14.141	19.214	24.545	41.92	60.77	77.08	99.78
Age squared	Total Family Involvement Percent $\geq 10$ : No	938	218.74	419.731	819.347	2386.6	4480.66	6442.12	9956.79
Age squared	Total Family Involvement Percent $\geq 10$ : Yes	905	199.968	340.315	479.613	1152.19	2698.59	4841.72	9563.53
Age squared	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	199.968	369.187	602.449	1757.22	3693.24	5941.13	9956.79
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : No	938	2	5	9	17	30	50	310
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes	905	2	7	11	20	33	55	375
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	2	6	10	18	31	53	375
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : No	938	0	0	0	5	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	0	6	8	10	10

Table 6. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Percentiles before Matching

	Treatment	N	Min	P10	P25	Median	P75	P90	Max
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	0	0	0	5	8	10	10
Propensity Score	Total Family Involvement Percent $\geq 10$ : No	938	0.006	0.074	0.171	0.33	0.55	0.7	0.94
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes	905	0.028	0.312	0.498	0.67	0.78	0.85	0.97
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1843	0.006	0.124	0.267	0.52	0.71	0.81	0.97

Table 7. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Percentiles after Matching

	Treatment	N	Min	P10	P25	Median	P75	P90	Max
Agitated Behavior Scale	Total Family Involvement Percent $\geq 10$ : No	507	14	14	14	15.4	19	23.64	45.57
Agitated Behavior Scale	Total Family Involvement Percent $\geq 10$ : Yes	507	14	14	14	15.76	19.13	24.13	42
Agitated Behavior Scale	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	14	14	14	15.64	19	23.93	45.57
Admission CSI Brain Inj	Total Family Involvement Percent $\geq 10$ : No	507	0	16	29	44	64	80	106
Admission CSI Brain Inj	Total Family Involvement Percent $\geq 10$ : Yes	507	0	20	29	48	65	78	111
Admission CSI Brain Inj	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	0	16	29	47	65	79	111
Admission CSI Non-Brain Inj	Total Family Involvement Percent $\geq 10$ : No	507	0	0	8	13	25	39	148
Admission CSI Non-Brain Inj	Total Family Involvement Percent $\geq 10$ : Yes	507	0	4	8	13	26	38	79
Admission CSI Non-Brain Inj	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	0	0	8	13	25	38	148
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : No	507	0	0	28	38	49	57	100
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes	507	0	0	24	38	49	56	90
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	0	0	24	38	49	57	100
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : No	507	0	0	20	35	44	50	83
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes	507	0	0	16	34	44	50	74
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	0	0	20	34	44	50	83
Age At Admission	Total Family Involvement Percent $\geq 10$ : No	507	14.79	19.266	24.167	40.04	59.9	75.72	96.48
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes	507	14.141	19.061	24.526	41.22	60.42	77.19	97.79
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	14.141	19.266	24.482	40.64	60.01	75.92	97.79
Age squared	Total Family Involvement Percent $\geq 10$ : No	507	218.74	371.189	584.044	1602.85	3587.85	5734.04	9308.22
Age squared	Total Family Involvement Percent $\geq 10$ : Yes	507	199.968	363.319	601.508	1698.95	3650.44	5958.45	9563.53
Age squared	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	199.968	371.189	599.362	1652	3601.31	5763.94	9563.53
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : No	507	2	6	10	18	30	51	310
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes	507	2	7	11	19	31	48	298
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	2	6	11	19	30	49	310
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : No	507	0	0	0	5	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes	507	0	0	0	5	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	0	0	0	5	8	10	10
Propensity Score	Total Family Involvement Percent $\geq 10$ : No	507	0.028	0.233	0.387	0.53	0.66	0.78	0.94
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes	507	0.028	0.233	0.387	0.53	0.65	0.77	0.94
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1014	0.028	0.233	0.387	0.53	0.65	0.78	0.94



Table 8. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Standardized Differences and Variance Ratios before Weighting

ACCEPTED MANUSCRIPT				
N=1,841	No (n=936)	Yes (n=905)	Standardised Differences	Variance Ratio Yes/No
Age at admission	49.6 (21.8)	39.1 (19.7)	0.504	0.81671
Age squared	2931.4 (2273.1)	1916.9 (1879.4)	0.486	0.6836
Days injury to rehab admission	25.1 (30)	28.9 (34.6)	0.115	1.33261
Admission FIM RASCH Motor	31.2 (16.6)	30.2 (18.5)	0.057	1.23756
Admission FIM RASCH Cognitive	36.8 (19.7)	34.7 (19)	0.111	0.93479
Admission CSI Brain Injury	44.5 (22.5)	49.1 (23.7)	0.199	1.11022
Admission CSI Non-Brain Injury	17.1 (14.9)	18.3 (15)	0.077	1.00986
Agitated Behavior Scale score average 1st 3 day	17.3 (4.3)	17.3 (4.3)	0.001	1.03316
Maximum Pain Score First 3 Days	4.3 (3.9)	4.7 (3.7)	0.089	0.93718
Sex male,	663 (70.8)	660 (72.9)	0.047	.
Marital status single	374 (40)	408 (45.1)	0.104	.
Marital status married	292 (31.2)	377 (41.7)	0.219	.
Marital status previously married	231 (24.7)	98 (10.8)	0.369	.
Marital status other	39 (4.2)	22 (2.4)	0.097	.
No prior brain injury	844 (90.2)	843 (93.1)	0.108	.
One prior brain injury	74 (7.9)	44 (4.9)	0.125	.
2+ prior brain injuries	18 (1.9)	18 (2)	0.005	.
Premorbid alcohol misuse	367 (39.2)	287 (31.7)	0.157	.
Premorbid drug use	233 (24.9)	166 (18.3)	0.16	.
High school education	644 (68.8)	688 (76)	0.162	.
Not a driver pre-injury	132 (14.1)	58 (6.4)	0.256	.
Driver pre-injury	577 (61.6)	763 (84.3)	0.528	.
Driving status unknown	227 (24.3)	84 (9.3)	0.409	.
Employed and Student	21 (2.2)	45 (5)	0.147	.
Employed Only,	394 (42.1)	466 (51.5)	0.189	.
Not Employed	146 (15.6)	106 (11.7)	0.113	.
Retired	291 (31.1)	136 (15)	0.388	.
Student Only	70 (7.5)	145 (16)	0.268	.
Unknown Employment)	14 (1.5)	7 (0.8)	0.068	.
Paralysis	353 (37.7)	360 (39.8)	0.042	.
Lived alone	180 (19.2)	71 (7.8)	0.337	.
Lived with significant other/spouse	327 (34.9)	453 (50.1)	0.309	.
Lived with family	327 (34.9)	292 (32.3)	0.057	.
Lived with other	102 (10.9)	89 (9.8)	0.035	.
Race white	652 (69.7)	741 (81.9)	0.288	.
Race white Hispanic	73 (7.8)	41 (4.5)	0.136	.
Race black	183 (19.6)	97 (10.7)	0.248	.
Race Asian, other or unknown	28 (3)	26 (2.9)	0.007	.
Cleared post-traumatic amnesia prior to admission	355 (37.9)	297 (32.8)	0.107	.
Payer: Medicare	275 (29.4)	116 (12.8)	0.415	.
Payer: Medicaid	190 (20.3)	129 (14.3)	0.16	.
Payer: Private	212 (22.6)	273 (30.2)	0.171	.
Payer: Workers Comp	51 (5.4)	62 (6.9)	0.058	.
Payer: Self or None	36 (3.8)	52 (5.7)	0.089	.
Payer: MCO HMO	93 (9.9)	194 (21.4)	0.32	.
Payer: No Fault Auto	45 (4.8)	46 (5.1)	0.013	.
Payer: Other	34 (3.6)	33 (3.6)	0.001	.
Cause of injury: fall	355 (37.9)	214 (23.6)	0.313	.
Cause of injury: sports or other	54 (5.8)	46 (5.1)	0.03	.
Cause of injury: moving vehicle crash	452 (48.3)	596 (65.9)	0.361	.
Cause of injury: violence	75 (8)	49 (5.4)	0.104	.
GCS: Intubated/Sedated or Missing	490 (52.4)	380 (42)	0.209	.
GCS: Mild	139 (14.9)	125 (13.8)	0.03	.
GCS: Moderate or Severe	307 (32.8)	400 (44.2)	0.236	.
Closed head injury with contusion or hemorrhage	685 (73.2)	620 (68.5)	0.103	.
Closed head injury without contusion or hemorrhage	176 (18.8)	226 (25)	0.15	.
Open head injury with contusion or hemorrhage	75 (8)	59 (6.5)	0.058	.
Facial fracture	115 (12.3)	136 (15)	0.08	.
Skull fracture	215 (23)	266 (29.4)	0.146	.
Subdural hematoma	467 (49.9)	392 (43.3)	0.132	.
Epidural hematoma	62 (6.6)	78 (8.6)	0.075	.
Subarachnoid hemorrhage	520 (55.6)	562 (62.1)	0.133	.
Intraventricular hemorrhage	162 (17.3)	181 (20)	0.069	.
Brain stem involvement	55 (5.9)	49 (5.4)	0.02	.
Premorbid behavioral control disorder	46 (4.9)	61 (6.7)	0.078	.
Premorbid learning disorder	41 (4.4)	47 (5.2)	0.038	.
Weight-bearing precautions 1st 3 days	202 (21.6)	228 (25.2)	0.085	.
Moderate-severe aphasia	484 (51.7)	436 (48.2)	0.071	.
Mild to severe ataxia	127 (13.6)	164 (18.1)	0.125	.
Site a	116 (12.4)	140 (15.5)	0.089	.
Site b	156 (16.7)	127 (14)	0.073	.
Site c	95 (10.1)	40 (4.4)	0.222	.
Site d	73 (7.8)	37 (4.1)	0.157	.
Site e	118 (12.6)	148 (16.4)	0.107	.
Site f	35 (3.7)	72 (8)	0.18	.

Table 8. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Standardized Differences and Variance Ratios before Weighting

	No (n=936)	Yes (n=905)	Standardised Differences	Variance Ratio Yes/No
Site g	142 (15.2)	303 (33.5)	0.437	.
Site h	145 (15.5)	26 (2.9)	0.448	.
Site i	56 (6)	12 (1.3)	0.25	.
Craniotomy	187 (20)	165 (18.2)	0.044	.
Craniectomy	69 (7.4)	60 (6.6)	0.029	.
Premorbid anxiety/depression	211 (22.5)	202 (22.3)	0.005	.
Premorbid chronic pain	152 (16.2)	140 (15.5)	0.021	.
Premorbid adult central nervous system disorder	130 (13.9)	56 (6.2)	0.258	.
Impaired activities of daily living premorbidly	49 (5.2)	28 (3.1)	0.107	.
Midline shift 0-5mm	133 (14.2)	106 (11.7)	0.074	.
Midline shift >5mm	110 (11.8)	100 (11)	0.022	.
Midline shift not otherwise specified	113 (12.1)	93 (10.3)	0.057	.
No midline shift	299 (31.9)	271 (29.9)	0.043	.
Unknown midline shift	281 (30)	335 (37)	0.149	.
Lived at home	898 (95.9)	888 (98.1)	0.129	.

	No	Yes	Standardised Differences	Variance Ratio Yes/No
Age at admission	38.9 (19.6)	39.1 (19.7)	0.01	1.00618
Age squared	1906.9 (1889.7)	1916.9 (1879.4)	0.01	0.98919
Days injury to rehab admission	27.3 (31.3)	28.9 (34.6)	0.05	1.22385
Admission FIM RASCH Motor	29.8 (17)	30.2 (18.5)	0.02	1.18442
Admission FIM RASCH Cognitive	33.9 (18.8)	34.7 (19)	0.04	1.02383
Admission CSI Brain Injury	50.9 (23.9)	49.1 (23.7)	0.08	0.9859
Admission CSI Non-Brain Injury	18.1 (15.3)	18.3 (15)	0.02	0.9606
Agitated Behavior Scale score average 1st 3 c	17.7 (4.3)	17.3 (4.3)	0.10	1.00054
Maximum Pain Score First 3 Days	4.7 (3.6)	4.7 (3.7)	0.01	1.081
Sex male,	651.8 (71.6)	660.0 (72.9)	0.03	.
Marital status single	400.2 (43.9)	408.0 (45.1)	0.02	.
Marital status married	389.7 (42.8)	377.0 (41.7)	0.02	.
Marital status previously married	97.4 (10.7)	98.0 (10.8)	0.00	.
Marital status other	23.5 (2.6)	22.0 (2.4)	0.01	.
No prior brain injury	853.1 (93.7)	843.0 (93.1)	0.02	.
One prior brain injury	45.0 (4.9)	44.0 (4.9)	0.00	.
2+ prior brain injuries	12.6 (1.4)	18.0 (2)	0.05	.
Premorbid alcohol misuse	294.1 (32.3)	287.0 (31.7)	0.01	.
Premorbid drug use	152.4 (16.7)	166.0 (18.3)	0.04	.
High school education	695.1 (76.3)	688.0 (76)	0.01	.
Not a driver pre-injury	50.9 (5.6)	58.0 (6.4)	0.03	.
Driver pre-injury	771.4 (84.7)	763.0 (84.3)	0.01	.
Driving status unknown	88.4 (9.7)	84.0 (9.3)	0.02	.
Employed and Student	42.4 (4.7)	45.0 (5)	0.02	.
Employed Only,	455.7 (50)	466.0 (51.5)	0.03	.
Not Employed	105.5 (11.6)	106.0 (11.7)	0.00	.
Retired	135.0 (14.8)	136.0 (15)	0.01	.
Student Only	163.3 (17.9)	145.0 (16)	0.05	.
Unknown Employment)	8.8 (1)	7.0 (0.8)	0.02	.
Paralysis	370.2 (40.6)	360.0 (39.8)	0.02	.
Lived alone	70.5 (7.7)	71.0 (7.8)	0.00	.
Lived with significant other/spouse	461.2 (50.6)	453.0 (50.1)	0.01	.
Lived with family	287.5 (31.6)	292.0 (32.3)	0.02	.
Lived with other	91.5 (10)	89.0 (9.8)	0.01	.
Race white	753.5 (82.7)	741.0 (81.9)	0.02	.
Race white Hispanic	35.9 (3.9)	41.0 (4.5)	0.03	.
Race black	98.8 (10.8)	97.0 (10.7)	0.00	.
Race Asian, other or unknown	22.6 (2.5)	26.0 (2.9)	0.02	.
Cleared post-traumatic amnesia prior to admission	277.9 (30.5)	297.0 (32.8)	0.05	.
Payer: Medicare	121.5 (13.3)	116.0 (12.8)	0.02	.
Payer: Medicaid	125.0 (13.7)	129.0 (14.3)	0.02	.
Payer: Private	278.5 (30.6)	273.0 (30.2)	0.01	.
Payer: Workers Comp	66.8 (7.3)	62.0 (6.9)	0.02	.
Payer: Self or None	52.7 (5.8)	52.0 (5.7)	0.00	.
Payer: MCO HMO	183.9 (20.2)	194.0 (21.4)	0.03	.
Payer: No Fault Auto	39.9 (4.4)	46.0 (5.1)	0.03	.
Payer: Other	42.5 (4.7)	33.0 (3.6)	0.05	.
Cause of injury: fall	217.9 (23.9)	214.0 (23.6)	0.01	.
Cause of injury: sports or other	43.4 (4.8)	46.0 (5.1)	0.01	.
Cause of injury: moving vehicle crash	591.6 (65)	596.0 (65.9)	0.02	.
Cause of injury: violence	57.9 (6.4)	49.0 (5.4)	0.04	.
GCS: Intubated/Sedated or Missing	365.2 (40.1)	380.0 (42)	0.04	.
GCS: Mild	126.8 (13.9)	125.0 (13.8)	0.00	.
GCS: Moderate or Severe	418.8 (46)	400.0 (44.2)	0.04	.
Closed head injury with contusion or hemorrhage	650.4 (71.4)	620.0 (68.5)	0.06	.
Closed head injury without contusion or hemorrhage	212.1 (23.3)	226.0 (25)	0.04	.
Open head injury with contusion or hemorrhage	48.3 (5.3)	59.0 (6.5)	0.05	.
Facial fracture	160.7 (17.6)	136.0 (15)	0.07	.
Skull fracture	295.5 (32.4)	266.0 (29.4)	0.07	.
Subdural hematoma	403.4 (44.3)	392.0 (43.3)	0.02	.
Epidural hematoma	83.1 (9.1)	78.0 (8.6)	0.02	.
Subarachnoid hemorrhage	558.8 (61.4)	562.0 (62.1)	0.02	.
Intraventricular hemorrhage	158.8 (17.4)	181.0 (20)	0.07	.
Brain stem involvement	46.0 (5)	49.0 (5.4)	0.02	.
Premorbid behavioral control disorder	49.6 (5.4)	61.0 (6.7)	0.05	.
Premorbid learning disorder	47.1 (5.2)	47.0 (5.2)	0.00	.
Weight-bearing precautions 1st 3 days	203.9 (22.4)	228.0 (25.2)	0.07	.
Moderate-severe aphasia	449.0 (49.3)	436.0 (48.2)	0.02	.
Mild to severe ataxia	171.6 (18.8)	164.0 (18.1)	0.02	.
Site a	130.7 (14.4)	140.0 (15.5)	0.03	.
Site b	113.6 (12.5)	127.0 (14)	0.05	.
Site C	45.3 (5)	40.0 (4.4)	0.03	.
Site d	39.0 (4.3)	37.0 (4.1)	0.01	.

	No	Yes	Standardised Differences	Variance Ratio Yes/No
Site e	136.5 (15)	148.0 (16.4)	0.04	.
Site f	78.6 (8.6)	72.0 (8)	0.02	.
Site g	329.3 (36.2)	303.0 (33.5)	0.06	.
Site h	26.5 (2.9)	26.0 (2.9)	0.00	.
Site i	11.3 (1.2)	12.0 (1.3)	0.01	.
Craniotomy	167.3 (18.4)	165.0 (18.2)	0.00	.
Craniectomy	76.2 (8.4)	60.0 (6.6)	0.07	.
Premorbid anxiety/depression	184.0 (20.2)	202.0 (22.3)	0.05	.
Premorbid chronic pain	142.9 (15.7)	140.0 (15.5)	0.01	.
Premorbid adult central nervous system disorder	50.2 (5.5)	56.0 (6.2)	0.03	.
premorbidity	33.3 (3.7)	28.0 (3.1)	0.03	.
Midline shift 0-5mm	100.8 (11.1)	106.0 (11.7)	0.02	.
Midline shift >5mm	91.4 (10)	100.0 (11)	0.03	.
Midline shift not otherwise specified	92.6 (10.2)	93.0 (10.3)	0.00	.
No midline shift	249.6 (27.4)	271.0 (29.9)	0.06	.
Unknown midline shift	376.3 (41.3)	335.0 (37)	0.09	.
Lived at home	897.9 (98.6)	888.0 (98.1)	0.04	.

Table 10. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Percentiles before Weighting

	Treatment	N	Min	P10	P25	Median	P75	P90	Max
Agitated Behavior Scale	Total Family Involvement Percent $\geq 10$ : No	936	14	14	14	15.5	18.89	23.45	45.57
Agitated Behavior Scale	Total Family Involvement Percent $\geq 10$ : Yes	905	14	14	14	15.64	18.75	23.24	42
Agitated Behavior Scale	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	14	14	14	15.55	18.82	23.36	45.57
Admission CSI Brain Injury	Total Family Involvement Percent $\geq 10$ : No	936	0	16	28	42	61	77	106
Admission CSI Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes	905	0	20	30	48	67	81	111
Admission CSI Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	17	29	44	64	79	111
Admission CSI Non-Brain Injury	Total Family Involvement Percent $\geq 10$ : No	936	0	0	8	13	24.5	36	148
Admission CSI Non-Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes	905	0	4	8	16	26	39	89
Admission CSI Non-Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	4	8	13	25	38	148
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : No	936	0	0	28	41	51	57	100
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	24	38	49	56	90
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	0	24	38	49	57	100
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : No	936	0	0	22	35	43	49	83
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	16	35	45	51	74
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	0	20	35	44	50	83
Age At Admission	Total Family Involvement Percent $\geq 10$ : No	936	14.79	20.526	28.691	48.87	66.99	80.26	99.78
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes	905	14.141	18.448	21.9	33.94	51.95	69.58	97.79
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	14.141	19.236	24.567	41.93	60.77	77.08	99.78
Age squared	Total Family Involvement Percent $\geq 10$ : No	936	218.74	421.303	823.193	2388.74	4487.08	6442.12	9956.79
Age squared	Total Family Involvement Percent $\geq 10$ : Yes	905	199.968	340.315	479.613	1152.19	2698.59	4841.72	9563.53
Age squared	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	199.968	370.029	603.524	1757.91	3693.24	5941.13	9956.79
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : No	936	2	5	9	17	29	50	310
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes	905	2	7	11	20	33	55	375
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	2	6	10	18	31	53	375
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : No	936	0	0	0	5	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	0	6	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	0	0	5	8	10	10
Propensity Score	Total Family Involvement Percent $\geq 10$ : No	936	0.006	0.074	0.171	0.33	0.55	0.7	0.94
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes	905	0.028	0.312	0.498	0.67	0.78	0.85	0.97
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0.006	0.124	0.267	0.52	0.71	0.81	0.97

Table 11. Balance Diagnostics for Hypothesis 2.2, Family Involvement: Percentiles after Weighting

	Treatment	N	Min	P10	P25	Median	P75	P90	Max
Agitated Behavior Score	Total Family Involvement Percent $\geq 10$ : No	936	14	14	14	15.88	20.18	24.76	45.57
Agitated Behavior Score	Total Family Involvement Percent $\geq 10$ : Yes	905	14	14	14	15.64	18.75	23.24	42
Agitated Behavior Score	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	14	14	14	15.75	19.47	24.13	45.57
Admission CSI Brain Injury	Total Family Involvement Percent $\geq 10$ : No	936	0	17	34	51	69	82	106
Admission CSI Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes	905	0	20	30	48	67	81	111
Admission CSI Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	20	32	49	68	82	111
Admission CSI Non-Brain Injury	Total Family Involvement Percent $\geq 10$ : No	936	0	4	8	13	25	39	148
Admission CSI Non-Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes	905	0	4	8	16	26	39	89
Admission CSI Non-Brain Injury	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	4	8	16	25	39	148
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : No	936	0	0	24	36	46	57	100
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	24	38	49	56	90
Admission FIM RASCH Cognitive	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	0	24	36	48	56	100
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : No	936	0	0	20	33	43	50	83
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	16	35	45	51	74
Admission FIM RASCH Motor	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	0	16	33	44	50	83
Age At Admission	Total Family Involvement Percent $\geq 10$ : No	936	14.79	18.932	21.728	33.34	53.09	69.63	99.78
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes	905	14.141	18.448	21.9	33.94	51.95	69.58	97.79
Age At Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	14.141	18.606	21.84	33.42	52.49	69.59	99.78
Age squared	Total Family Involvement Percent $\geq 10$ : No	936	218.74	358.43	472.088	1111.84	2818.22	4848.96	9956.79
Age squared	Total Family Involvement Percent $\geq 10$ : Yes	905	199.968	340.315	479.613	1152.19	2698.59	4841.72	9563.53
Age squared	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	199.968	346.199	476.978	1116.59	2754.92	4843.25	9956.79
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : No	936	2	7	11	19	31	52	310
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes	905	2	7	11	20	33	55	375
Days from Injury To Rehab Admission	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	2	7	11	20	32	54	375
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : No	936	0	0	0	5	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes	905	0	0	0	6	8	10	10
Max Pain Score First 3 Days	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0	0	0	5	8	10	10
Propensity Score	Total Family Involvement Percent $\geq 10$ : No	936	0.006	0.305	0.501	0.66	0.8	0.85	0.94
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes	905	0.028	0.312	0.498	0.67	0.78	0.85	0.97
Propensity Score	Total Family Involvement Percent $\geq 10$ : Yes and No Combined	1841	0.006	0.31	0.499	0.67	0.79	0.85	0.97

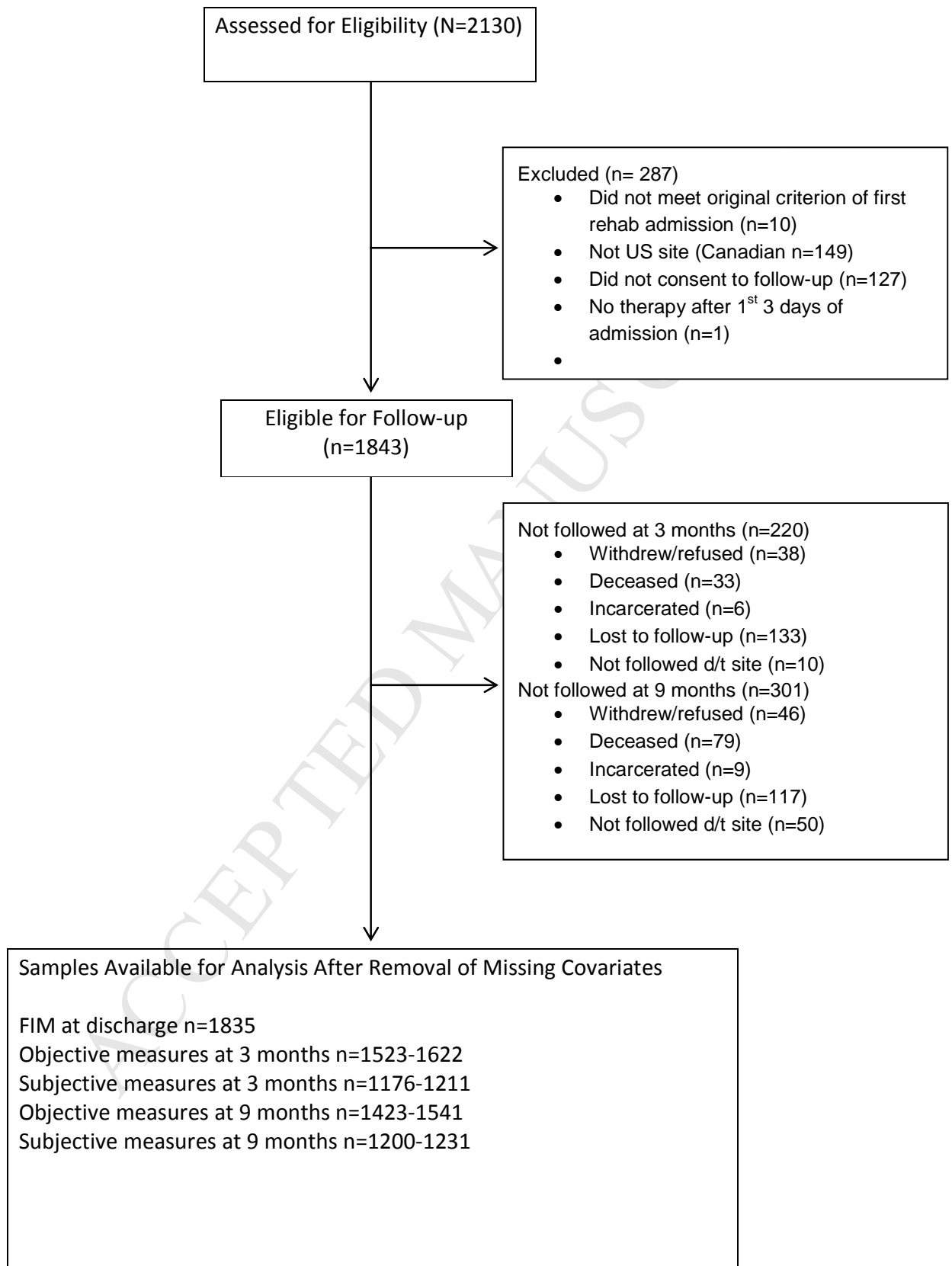
SDC Table: Older Participants, Adjusted<sup>^</sup> regressions

	Time Point	Sample	N	Difference	Lower 95% CI	Upper 95% CI	p- value
PART-O Total	3-Month	Matched	154	0.14	-0.04	0.31	0.12
PART-O Total	9-Month	Matched	144	0.14	-0.01	0.30	0.06
PART-O Total	3-Month	Weighted	307	0.24	0.10	0.38	<b>&lt;0.01</b>
PART-O Total	9-Month	Weighted	288	0.30	0.15	0.46	<b>&lt;0.01</b>
PART-O Total Rasch	3-Month	Matched	133	2.86	-0.64	6.36	0.11
PART-O Total Rasch	9-Month	Matched	130	1.06	-1.68	3.79	0.45
PART-O Total Rasch	3-Month	Weighted	265	2.07	-0.67	4.80	0.14
PART-O Total Rasch	9-Month	Weighted	249	3.16	0.48	5.83	<b>0.02</b>
PART-O Out and About	3-Month	Matched	154	0.29	0.04	0.55	<b>0.02</b>
PART-O Out and About	9-Month	Matched	145	0.18	-0.05	0.41	0.12
PART-O Out and About	3-Month	Weighted	307	0.32	0.12	0.51	<b>&lt;0.01</b>
PART-O Out and About	9-Month	Weighted	289	0.35	0.16	0.55	<b>&lt;0.01</b>
PART-O Productivity	3-Month	Matched	157	0.10	-0.08	0.28	0.26
PART-O Productivity	9-Month	Matched	145	0.01	-0.19	0.21	0.93
PART-O Productivity	3-Month	Weighted	310	0.10	-0.05	0.26	0.19
PART-O Productivity	9-Month	Weighted	290	0.06	-0.11	0.23	0.50
PART-O Social	3-Month	Matched	156	0.00	-0.27	0.27	0.99
PART-O Social	9-Month	Matched	144	0.27	0.02	0.53	<b>0.04</b>
PART-O Social	3-Month	Weighted	309	0.30	0.05	0.54	<b>0.02</b>
PART-O Social	9-Month	Weighted	288	0.51	0.28	0.74	<b>&lt;0.01</b>
FIM Rasch Cog	Discharge	Matched	190	-0.12	-4.08	3.85	0.95
FIM Rasch Cog	3-Month	Matched	150	0.04	-6.60	6.68	0.99
FIM Rasch Cog	9-Month	Matched	135	1.63	-5.60	8.87	0.65
FIM Rasch Cog	Discharge	Weighted	381	0.98	-1.76	3.72	0.48
FIM Rasch Cog	3-Month	Weighted	295	0.44	-4.93	5.82	0.87
FIM Rasch Cog	9-Month	Weighted	263	5.72	-0.28	11.72	0.06
FIM Motor Rasch	Discharge	Matched	190	0.08	-3.25	3.41	0.96
FIM Motor Rasch	3-Month	Matched	145	2.39	-4.40	9.17	0.49

FIM Motor Rasch	9-Month	Matched	129	2.40	-5.70	10.50	0.56
FIM Motor Rasch	Discharge	Weighted	381	0.15	-2.77	3.06	0.92
FIM Motor Rasch	3-Month	Weighted	286	1.33	-4.22	6.88	0.64
FIM Motor Rasch	9-Month	Weighted	252	2.68	-4.00	9.37	0.43
Satisfaction With Life	3-Month	Matched	99	0.18	-2.63	3.00	0.90
Satisfaction With Life	9-Month	Matched	99	0.39	-2.84	3.62	0.81
Satisfaction With Life	3-Month	Weighted	190	1.06	-1.37	3.49	0.39
Satisfaction With Life	9-Month	Weighted	194	1.81	-1.05	4.66	0.21
PHQ-9*	3-Month	Matched	77	0.67	0.21	2.13	0.50
PHQ-9*	9-Month	Matched	96	2.18	0.63	7.49	0.22
PHQ-9*	3-Month	Weighted	140	0.86	0.32	2.33	0.77
PHQ-9*	9-Month	Weighted	188	2.46	0.89	6.81	0.08

\*Odds ratio; ^Matched analysis adjusted for: driving status, craniectomy/craniotomy, and premorbid history of difficulties with activities of daily living; Weighting analysis adjusted for: age, admission FIM Cognitive, and one site.





### Methodology Details

Calculation of Family Involvement in Treatment. FI was operationalized as attendance by any family member or friend during at least 10% of all treatment minutes provided by occupational, physical, speech, recreational therapists, or psychologists. Minutes of therapist time rather than patient time in treatment were used. Approximately 3% of the full sample's treatment minutes involved co-treatment, which was considered negligible. Treatment began to be counted after the 4<sup>th</sup> day of the admission, since assessments primarily occur during the first 3 days.

Formula for Inverse Probability Treatment Weighting. IPTW weights exposed (FI $\geq$ 10%) participants by 1 and those not exposed by  $\frac{e}{1-e}$ . This formula allows estimation of the average treatment effect in the treated (ATT) (the estimand also obtained via matching) rather than the average treatment effect (ATE) estimated by the typical weight calculation.<sup>33</sup>

Multiple imputation models: Multiple imputation models, by chained equations with predictive mean matching for continuous outcomes and K-nearest neighbors for categorical variables, included all outcomes, treatments and covariate, as well as interaction effects explored between LOE and Compliance, and severity and outcomes. The "treatments" included all interventions that were tested in the parent comparative effectiveness study.