TBI Patient, Injury, Therapy, and Ancillary Treatments Associated with Outcomes at Discharge and 9 Months Post-discharge

Susan D. Horn, PhD[a], **John D. Corrigan, PhD**[b], **Cynthia L. Beaulieu, PhD, ABPP**[c], **Jennifer Bogner, PhD**[b], **Ryan S. Barrett, MS**[a], **Clare G. Giuffrida, PhD, OT/L, FAOTA**[d], **David K. Ryser, MD**[e], **Kelli Cooper, PT, DPT, NCS**[e], **Deborah M. Carroll, MS, CCC-ST**[e], and **Daniel Deutscher, PT, PhD**[f]

[a]Institute for Clinical Outcomes Research, International Severity Information Systems, Inc, Salt Lake City, UT

[b]Department of Physical Medicine and Rehabilitation, Ohio State University, Columbus, OH

[c]Brooks Rehabilitation Hospital, Jacksonville, FL

[d]Rush University Medical Center, Chicago, IL

[e]Neuro Specialty Rehabilitation Unit, Intermountain Medical Center, Salt Lake City, UT

[f]Maccabi Healthcare Services, Tel Aviv, Israel

Abstract

Corresponding author: Susan D. Horn, PhD, 699 East South Temple, Suite 215, Salt Lake City, Utah 84102, Office: 801-466-5595 x203, Home: 801-718-9149, shorn@isisicor.com.

Objective—To examine associations of patient and injury characteristics, inpatient rehabilitation therapy activities, and neurotropic medications with outcomes at discharge and 9 months post-discharge for patients with traumatic brain injury (TBI)

Design—Prospective, longitudinal observational study

Setting—10 inpatient rehabilitation centers (9 US, 1 Canada)

Participants—Consecutive patients (n=2130) enrolled between 2008 and 2011, admitted for inpatient rehabilitation after an index TBI injury

Interventions—Not applicable

Main Outcome Measures—Rehabilitation length of stay, discharge to home, and Functional Independence Measure (FIM) at discharge and 9 months post-discharge

Results—The admission FIM Cognitive score was used to create 5 relatively homogeneous subgroups for subsequent analysis of treatment outcomes. Within each subgroup, significant associations were found between outcomes and patient and injury characteristics, time spent in therapy activities, and medications used. Patient and injury characteristics explained on average 35.7% of the variation in discharge outcomes and 22.3% in 9-month outcomes. Adding time spent and level of effort in therapy activities, as well as percent of stay using specific medications, explained approximately 20.0% more variation for discharge outcomes and 12.9% for 9-month outcomes. After patient, injury, and treatment characteristics were used to predict outcomes, center differences added only approximately 1.9% additional variance explained.

Conclusions—At discharge, greater effort during therapy sessions, time spent in more complex therapy activities, and use of specific medications were associated with better outcomes for patients in all admission FIM Cognitive subgroups. At 9 months post-discharge, similar but less pervasive associations were observed for therapy activities, but not classes of medications. Further research is warranted to examine more specific combinations of therapy activities and medications that are associated with better outcomes.

A major challenge in traumatic brain injury (TBI) inpatient rehabilitation practice is how best to customize available resources to optimize patient outcomes. Many previous studies have examined only the effects of patient and injury characteristics on outcomes.[1–7] The association of TBI rehabilitation outcomes with processes of care has not been studied comprehensively. Studies that have examined treatments have focused on specific rehabilitation techniques or aggregate time in physical (PT), occupational (OT), or speech (ST) therapy. [8–14] However, several of these investigators concluded that the potential impact of multiple confounding variables were not accounted for and that research was needed to move beyond the simple question of whether aggregate measures of rehabilitation time or rehabilitation programs were effective. Research needs to examine factors such as specific activities performed during therapy sessions and salient patient characteristics that optimize clinical outcomes. TBI rehabilitation studies typically have been limited to a single set or subset of interventions and rarely examine multiple processes of care concurrently.

Failure to optimize rehabilitation therapies and treatment interventions can result in too few or too many resources relative to a patient's needs and preferred outcomes.

The introductory article in this series describes the purpose, design, and scope of the overall study, as well as a literature review that establishes the case for the multicenter, TBI practice-based evidence study (TBI-PBE).[15] Other articles in this series have documented the nature, scope, and variation of TBI rehabilitation practice as observed in this study,[16–18] which was designed to identify associations among TBI rehabilitation patient and injury characteristics, therapeutic processes, and outcomes.[15] Clinicians and researchers defined granular details of the care rendered. Previous studies have not included sufficient detail to determine how various services—alone, in combination, or sequentially—predict functional independence, length of stay (LOS), and discharge to a private residence. Previous studies have focused only on the amount of therapy provided daily or weekly, rather than the actual content of therapy provided and the patient's participation in the session.[12,19] In contrast, the present study sought to determine what therapeutic activities should be provided, to whom, and under what conditions.

In the current article, rehabilitation factors described in the earlier papers were integrated in order to examine the cumulative contribution of individual and rehabilitation factors to outcomes. Predictors fell into three general categories: (1) patient and injury characteristics, (2) discipline-specific activities and the effort given to treatment, and (3) use of neurotropic medications. Six outcomes were predicted: LOS in acute rehabilitation, discharge from rehabilitation to a private residence, and motor and cognitive functional independence at discharge and 9 months post-discharge. We sought to determine how specific rehabilitation activities—therapies and medications—relate to outcomes when patient and injury characteristics have been fully accounted for.

METHODS

From October 2008 to September 2011, patients with a primary diagnosis of TBI who were consecutively admitted to 10 acute inpatient rehabilitation facilities were enrolled in the TBI-PBE study. The methodology of the study is fully described elsewhere, including participating facilities, patient selection criteria, validity and reliability of data collection instruments, and a detailed description of the cohort.[15, 20] The 10 participating centers constituted a convenience sample of TBI adult inpatient rehabilitation centers based on their willingness to conduct the research; however, the sample closely resembled the US population of adolescents and adults receiving acute rehabilitation for a primary diagnosis of TBI.[15] The Institutional Review Board at each center approved the study; each patient or his/her proxy gave informed consent.

Participants

All patients enrolled and consented in the study (n=2130) were eligible for inclusion in the analyses reported here. Participants (a) sustained a TBI, defined as damage to brain tissue caused by an external force and evidenced by loss of consciousness, post-traumatic amnesia, skull fracture, or objective neurological findings, (b) received inpatient care at one of the 10 participating facilities, and (c) were at least 14 years of age or older upon entry into the

facility. Fairly homogenous patient subgroups were formed using the Functional Independence Measure (FIM™) Cognitive score upon admission to rehabilitation. FIM is a measure of functional independence, and consists of 18 items in two domains: Motor (13 items) and Cognitive (5 items). Each item is rated on a 7-point scale, ranging from 1: total assistance, to 7: complete independence. The five homogenous subgroups of patients based on admission FIM Cognitive were defined as follows: scores 6 (n=339), 7–10 (n=374), 11–15 (n=495), 16–20 (n=408), and 21 (n=504). Ten patients missing admission FIM Cognitive scores were not included in subsequent analyses. More details about these subgroups are presented elsewhere.[15]

A listing of all variables capturing patient and injury characteristics that were eligible for inclusion in prediction models can be found in table 1. Only variables actually included in at least one final model are described here. Patient variables were comprised of (a) *demographic characteristics* (age, gender, race categories, education [some high school, but no diploma], payer [Medicaid]); (b) *pre-injury health information* (indication of substance use and body mass index less than 18.5 [based on the Center for Disease Control definition of underweight]); (c) *injury and rehabilitation stay characteristics* (presence of anxiety or depression, percent of rehabilitation stay agitated, days from injury to rehabilitation admission, presence of post-traumatic amnesia upon admission to rehabilitation, Comprehensive Severity Index [CSI®] scores); and (d) *functional status characteristics* (admission functional status [Rasch-transformed admission FIM Motor and FIM Cognitive scores]).[21]

CSI is a disease-specific severity assessment system that calculates severity scores using physical exam findings, vital signs, and laboratory results at specified levels of abnormality found in a patient's chart. CSI is based on diseases defined by *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) and was segmented into signs and symptoms directly related to the brain injury versus all remaining severity symptoms.[15]

Treatments

Treatments studied were separated into three categories: (a) total minutes per week spent in therapy and level of effort, (b) minutes per week spent in specific activities provided by clinicians from various disciplines including OT, PT, ST, psychology (PSY), and therapeutic recreation (TREC); and (c) percent of the inpatient stay the patient received various pharmacological classes of medications. More detailed information on medication prevalence and use patterns in this sample is presented elsewhere.[18] Because of the large number of therapy activities, some collapsing was necessary so that models were not over-specified. OT, PT, and ST activity collapses can be found in detail elsewhere.[16] For PSY activities, originally stratified by patient, family, and patient & family minutes, we combined the time spent with patient, family, or both for each PSY activity. TREC activities were grouped into sports, arts, music, cognitive activities, other, and community reintegration. Additional collapsing within each discipline was made for highly correlated (|r|>0.6) and similarly complex activities, but never across disciplines.

To assess each patient's effort in therapy we also included a single OT/PT/ST average level of effort over the rehabilitation stay as measured by a clinician-rated effort score. Level of

effort was measured using the Rehabilitation Intensity of Therapy Scale (RITS), which is a single item, 7-point scale, behaviorally anchored by a hierarchy of observable levels of 60 goal-directed activities including initiating, attending to, and sustaining an activity. Further details about this measure are presented elsewhere.[22]

Outcomes

Six outcome variables were studied: LOS (which excludes days out of the rehabilitation facility resulting from readmission to acute care), discharge destination (private residence versus institutional setting), and Rasch-transformed FIM Motor and Cognitive scores at two time points: discharge from rehabilitation and 9 months post-discharge.

Data Analyses

Analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC). When data were missing, one or more adjustments were made depending on the variable and its intended use in analyses. In some instances, we categorized values simply as "unknown" (and included this category in analysis as a dummy variable representing absent data); in other instances we collapsed a continuous variable with missing data into a categorical one and placed the cases with missing information into one of these categories using corroborating data available. In some circumstances missing data resulted in an observation being excluded from a specific model—final sample sizes are reported for all models. Examples are the following: Patients missing continuous measure predictors were allowed to fall out of the models (e.g., 10 patients were missing admission FIM cognitive or motor score, and thus fell out of the model). BMI, while continuous, was broken into <18.5 vs >18.5, where missing was lumped into the reference category (>18.5), since these patients were more similar to one another. Patients who did not receive psychology or therapeutic recreation would necessarily be missing for those variables; we decided to assign these patients a 0 for each activity.

Descriptive statistics were used to provide frequencies and percentages for categorical variables describing patients, treatments, and outcomes; mean, median, quartiles, and standard deviation (SD) were used to summarize continuous measures. Bivariate analyses were conducted to examine differences among FIM Cognitive subgroups. For discrete variables, we used the Fisher's Exact test or chi-square test to determine significance. For continuous variables we used t-tests, analysis of variance (ANOVA), or the Kruskal-Wallis test. A two-sided p value <0.05 was considered statistically significant.

The intraclass correlation coefficient (ICC) due to site (how strongly patients in the same site resemble one another) and using the full study sample (not divided into subgroups) for the 6 outcomes ranged from 0.03 to 0.10 for all outcomes except Rasch-transformed discharge FIM Motor score, with ICC of 0.22. After dividing into FIM Cognitive subgroups, the average ICC for each outcome ranged from 0.06 to 0.12 for all outcomes except Rasch-transformed discharge FIM Motor score, with average ICC of 0.18. None of these ICC values is very high, so it justifies using ordinary least squares (OLS) to analyze the data, without the need to nest on site.

To assess associations between covariates and outcomes, we used OLS multiple regression or logistic regression. Variables with at least 20 observations that were allowed to enter into the regression models were checked for multi-collinearity. If a correlation |0.60| was observed, one of the pair of variables was removed. The most parsimonious models were created for each of six outcomes within each of the five admission FIM Cognitive subgroups by allowing only significant (p<.05) variables to remain in the models. Variables entering any model and their descriptive statistics are shown in table 1. We used R^2 and c statistics to capture how much variation in an outcome was explained by the predictor variables.

Covariates were allowed to enter and be added into each model in one of five blocks: (1) patient and injury characteristics, (2) discipline-specific total minutes/week, (3) percent of stay on medications from each of 8 pharmacological classes (defined elsewhere),[18] (4) level of effort (LOE), (5) discipline-specific activity minutes/week, and (6) centers participating in the study. We computed the amount of variation explained when we allowed various combinations of the variable blocks to enter models predicting outcomes. Eight combinations of the blocks of variables numbered above were examined: block 1; blocks 1 and 2; blocks 1 and 3; blocks 1 and 4; blocks 1 and 5; blocks 1, 4, and 5; blocks 1, 3, 4, and 5; and blocks 1, 3, 4, 5, and 6. Within block 6, the centers participating in the study were included to determine whether a significant source of between-center differences remained unexplained after the final model that included all therapeutic activities, LOE, and medications.

RESULTS

Patient, Process, and Outcome Characteristics

Table 1 shows how the 5 FIM Cognitive subgroups differed by predictor and outcome variables. All patient demographic, injury and health, and functional status characteristics except race (p=.083) were significantly different (p<.02) among the admission FIM Cognitive subgroups. The lower cognitive functioning subgroups had more days from injury to rehabilitation admission, lower admission FIM motor scores, tended to be younger, had a larger proportion of patients classified as underweight, a larger proportion of patients with Medicaid as the primary payer, more severe CSI component scores, were agitated for a larger percentage of their rehabilitation stay, and had lower average OT/PT/ST level of effort scores. The greatest percent of patients with anxiety and depression were in the middle admission FIM Cognitive subgroups 7–10 and 11–15 subgroups. Although the number of patient and injury characteristics used in these analyses were fewer when compared to the number of patient individual differences used by Corrigan et al.,[23] the total amount of variance accounted for by patient and injury characteristics alone used in this analysis was comparable to that resulting from the more comprehensive starting point.

The data collected demonstrated extreme variation within and between FIM Cognitive subgroups with respect to amount of time spent in various discipline-specific activities. The higher functioning subgroups (admission FIM Cognitive score 16) received less OT, PT, and ST total minutes/week than did the lower functioning subgroups (admission FIM Cognitive score 10). PSY and TREC showed a bell-shaped pattern with the middle functioning subgroups (admission FIM Cognitive score between 11 and 20) receiving the

most minutes/week. For many activities across each of the disciplines, the standard deviation was bigger than the mean minutes/week, suggesting that even within the relatively homogenous admission FIM Cognitive subgroups, there was significant treatment variation.

Between admission and discharge, all subgroups showed improved outcomes for Rasch-transformed FIM Motor and Cognitive scores, with the lower functioning subgroups generally receiving more therapeutic activities compared to the higher functioning subgroups. Going from lower to higher functioning subgroups, the change in Rasch-transformed FIM Motor scores from admission to discharge went from 33.3 points to 16.1 points decreasing monotonically across higher subgroups. For Rasch-transformed FIM Cognitive scores, the change from admission to discharge went from 37.7 points to 8.7 points decreasing monotonically. Also, improvement in outcomes was seen between discharge and 9 months post-discharge in both higher and lower functioning patients (see table 1).

Classes of medications used also varied greatly between and within admission FIM Cognitive subgroups. Lower functioning patients (admission FIM Cognitive score 10) tended to use narcotic-analgesics for a smaller percentage of their rehabilitation stay, and a larger percentage of their stay using antianxiety agents, antiparkinson agents, older antidepressants, second-generation antipsychotics, hypnotics, and stimulants. Standard deviations were often larger than means, again suggesting great variation in use within admission FIM Cognitive subgroups.

All outcomes (except discharge to a private residence in the 11–20 admission FIM Cognitive subgroup) showed a monotonic relationship across FIM Cognitive subgroups—lower functioning patients tended to have longer lengths of stay, smaller proportions discharged to a private residence, and lower Rasch-transformed FIM Motor and Cognitive scores at discharge and 9 months post-discharge.

Ordinary Least Squares and Logistic Regression Results

Table 2 shows the number of patients included in each model, along with the R^2 values for blocks of variables for continuous outcomes, and c-statistics for blocks of variables for the dichotomous discharge destination. Patient and injury characteristics alone explained from 10% to 71% of the variation in discharge outcomes. On average, patient and injury characteristics explained much more variation in Rasch-transformed FIM Motor scores at discharge than in either the Rasch-transformed FIM Cognitive scores at discharge or rehabilitation length of stay. In contrast, patient and injury characteristics alone explained from 5% to 39% of the variation in 9-month outcomes. When total discipline-specific therapy minutes/week were allowed to enter, little additional explanatory power resulted beyond that found for patient and injury characteristics (between 0% and 5%, with a mean added R^2 of 1.5% across subgroups and outcomes).

There were greater increases in explanatory power when time for each discipline was broken down by specific activities performed. When minutes/week of discipline-specific activities were allowed to enter the models, the mean added value of R^2 was 13.1% (14.1% for discharge outcomes and 11.6% for 9-month outcomes) compared to the R^2 for patient and

injury characteristics alone. When OT/PT/ST patient effort in therapy was added, in addition to discipline-specific activities, the increase was higher: 16.4% average added R^2 (19.3% for discharge outcomes and 11.9% for 9-month outcomes).

For all outcomes and within every admission FIM Cognitive subgroup, medication use added less to the variation explained than did the discipline-specific activities. When medications were added to patient and injury characteristics and time and effort spent in discipline-specific activities, the mean added R^2 was less than 2% beyond the mean R^2 without medications. The block of variables indicating which center a patient was treated in also added little explanatory power. The most variance accounted for by site indicators was an additional 8% for the model predicting discharge FIM cognitive in the admission FIM Cognitive subgroup >21; the mean added R^2 was 1.9% beyond that of patient, injury, activity times, level of effort, and medications (see table 2).

Figures 1 through 6 show regression model details for the 6 outcome variables for each of the 5 admission FIM Cognitive subgroups. Models include patient and injury characteristics, patient effort, minutes/week spent in discipline-specific activities, and percent of the rehabilitation stay on given classes of medications. Each subgroup model includes three columns: the least squares regression (OLS) coefficient (parameter), the standardized coefficient estimating the effect of the variable, and p-value. Additionally, in the right hand columns there are colored cells that represent the associated relative strength of each significant variable's effect on the outcome being modeled. This effect is measured by multiplying the OLS regression coefficient estimate by the subgroup mean value of that covariate (or by the prevalence of binary factors). For example, in the admission FIM Cognitive 6 subgroup model predicting rehabilitation LOS, the parameter estimate for Rasch-transformed admission FIM Motor is −0.422 while the effect on LOS is −4.85 indicating a covariate mean value in this subgroup of −4.85/−0.422 = 11.5. The interpretation for this relationship is that a 1-point increase in Rasch-transformed admission FIM Motor score is associated with a 4.85 day *decrease* in the patient's rehabilitation LOS for the average patient in the lowest functioning subgroup, controlling for other variables in the model. Darker or lighter green cells indicate a stronger or weaker positive effect, respectively, while darker or lighter red cells indicate a stronger or weaker negative effect on the outcome.

Figure 7 shows a high-level summary of the significant variables in figures 1 through 6 for each dependent variable by admission FIM Cognitive subgroup. Cells containing "LoS" (rehabilitation length of stay), "dcH" (discharge to home), "dcM" (discharge FIM Motor), "dcC" (discharge FIM Cognitive), "fuM" (9-month post-discharge FIM Motor), or "fuC" (9-month post-discharge FIM Cognitive) indicate that in the final model for the specified dependent variable the covariate in the row is a significant predictor (p<.001 if bolded, and p<.05 if not). Red values indicate a negative association (coefficient), while green values indicate a positive one.

Examples of how to read figure 7 follow. In every case, the parameter estimate is with all other variables in the model held constant. Older patients in every subgroup had lower discharge and 9-month FIM Motor scores, were less likely to go home, and had lower 9-

month FIM Cognitive scores in all but the two highest functioning subgroups. Patients who were able to give greater effort in therapy (as measured by higher clinician-rated effort score) have generally higher discharge and 9-month Motor and Cognitive FIM scores, and are more likely to be discharged to a private residence. Most patients who had more days from injury to rehabilitation admission had longer lengths of stay, were discharged with lower Motor and Cognitive FIM scores, and had lower 9-month FIM scores.

Therapeutic activities associated with outcomes differed between the subgroups. For example, more time spent in patient education during OT sessions was associated with a higher likelihood of going home in the three lowest functioning subgroups, and was associated with a shorter length of stay in the three highest functioning subgroups. There were additional positive associations with cognitive function and more OT patient education minutes/week in the lowest functioning subgroup (e.g., higher 9-month FIM Cognitive scores). More time spent in advanced activities (whether cognitive or physical) was often associated with better outcomes in all subgroups and across all dependent variables. For example, in the lowest functioning subgroup, more time spent in ST activities that involved problem solving, math or money, and memory was associated with higher discharge and 9-month FIM Motor and Cognitive scores. These same ST activities were associated with higher scores for one or more of those same outcomes in all other subgroups except admission FIM Cognitive 11–15. More minutes/week spent in activities such as PT equipment management, wheelchair mobility, casting, and transitional movements were associated with poorer outcomes across all admission FIM Cognitive subgroups, except the lowest and highest scoring cognitive groups.

Percent of a patient's rehabilitation stay involving the use of certain pharmacological classes of medications had varying associations with outcomes among admission FIM Cognitive subgroups. A larger percentage of a patient's stay involving the use of nonnarcotic-analgesics, for example, was associated with a higher discharge FIM Motor score, but lower 9-month follow-up scores in the 7–10 subgroup, while in the 16–20 FIM Cognitive subgroup, higher discharge FIM Cognitive but lower 9-month FIM Motor and Cognitive scores were found. Patients in the admission FIM Cognitive 11–15 subgroup on second-generation antipsychotics for a larger percentage of their stay had higher discharge FIM Cognitive scores; patients with admission FIM Cognitive 6 showed higher discharge FIM Motor scores in addition to Cognitive, but also had a longer associated rehabilitation LOS. A larger percentage of the rehabilitation stay on hypnotics was associated with either a higher likelihood of going home, or higher discharge FIM Motor and Cognitive scores in the three highest functioning subgroups.

DISCUSSION

The purpose of PBE designs is to identify associations between numerous patient, injury, treatment, and outcome variables. PBE designs increase the likelihood that associations will replicate in other cohorts, due largely to the inclusion of many covariates in the models adding strength to the robustness of the findings. The specific aim of this PBE study was to examine which patient and injury characteristics, therapy activities, and classes of medication are associated with better outcomes at discharge from acute inpatient

rehabilitation and at 9-months post-discharge. We found consistencies in associations for most patient pre-injury and injury characteristics, as well as most therapy activities, across all five admission FIM Cognitive subgroups. That is, if a variable was associated with a positive outcome for one FIM Cognitive subgroup then it usually was positive in other FIM Cognitive subgroups. For those therapy activities associated with outcomes, a critical question is whether the activity is a marker of the directionality of the outcome (i.e., poorer or better), or a cause of it? If the latter, there may be opportunities to better deploy therapy time or optimize medication use.

At a macro level, several observations that were evident across dependent variables merit discussion. For all dependent variables, including effort in therapy and time in specific activities increased prediction beyond that attained using only total time in therapy. Furthermore, in some analyses the increases were quite marked. For instance, for discharge FIM Cognitive, the addition of effort in therapy and the specific activities employed by therapists more than doubled the percent of variance accounted for in four of the five admission FIM Cognitive subgroups.

A second macro observation of note was that rehabilitation LOS minimally affected prediction of outcomes when allowed to enter models as a treatment characteristic. This variable was not included in final models due to LOS adding little to explanatory power of the models and in some cases beneficial activity variables were subsumed by LOS. The insignificance of LOS as a variable is the second variable associated with time that did not provide predictive power (total therapy time is the other variable).

A third macro observation was the consistency with which the inclusion of specific therapy activities increased prediction over models that relied only on patient and injury characteristics. For continuous outcomes at discharge from inpatient rehabilitation, the smallest additional percent of variance accounted for was approximately 2%, and the largest was almost 45%. This phenomenon was more pronounced in lower functioning subgroups. All three of these macro observations underscore the importance of knowing what actually takes place in the therapeutic encounter to predict outcomes. Knowing only aggregates of time, whether it be total time in therapy or LOS, is not as strongly associated with outcome as time spent in specific therapy activities utilized.

Longer time from day of injury to rehabilitation admission is a patient injury characteristic that was consistently found to be strongly associated with poorer outcomes, specifically longer rehabilitation LOS and lower FIM Motor and Cognitive scores at discharge and 9-months post-discharge. This relationship was also observed in the PBE stroke study and has been reported by a variety of other authors.[24–33] Acute LOS clearly is prolonged with more severe brain injury and greater secondary injuries; however, in our study acute LOS (i.e., day of injury to rehabilitation admission) added more to prediction than direct measures of injury severity. Wagner suggested that one way to decrease acute LOS is early consultation by a physical medicine and rehabilitation specialist.[33] However, what determines timing of transfer to rehabilitation admission is complicated, and influenced by patient and medical status, payer policies, acute to post-acute facility relationships, and availability of post-acute facilities. Even though evidence suggests that earlier transfer to rehabilitation may lead to

better patient outcomes, as this study suggests, if the rehabilitation facility is not reimbursed adequately for addressing acute medical issues, a strong disincentive exists to admit these patients sooner post-injury. Clinical experience from the past decade of change in rehabilitation practices has shown that a higher level of preparation is necessary to manage more medically acute patients who transfer from acute care soon after injury.

Rehabilitation practice traditionally has been based on the assumption that there is a sequence of recovery that must be followed to restore normal function, and that challenging patients too quickly or encouraging compensatory strategies too early will be counterproductive.[28–31] However, findings from this study argue against this assumption. We found significantly better outcomes across all admission FIM Cognitive subgroups were associated with more minutes/week spent in advanced or more complex activities and less time spent in lower level or less complex activities. This finding was demonstrated across all three of the primary disciplines—OT, PT, and ST—and replicates findings from previous PBE studies for stroke and pediatric rehabilitation populations.[24, 25] Practice-based evidence studies with stroke patients found that therapy that challenges patients with severe impairments, such as therapies targeting advanced gait (negotiating uneven surfaces), home management, and problem-solving, were associated with better outcomes than therapies targeting lower level functions such as bed mobility and basic speech.[24,32,33] Moreover, those studies found that better outcomes were associated with using advanced therapies earlier in treatment. Challenging activities may be more meaningful and familiar to patients (e.g., ambulating in the community versus down the hospital hall), and potentially could increase motivation to participate in treatment.

As with other findings from the current study, causation cannot be assumed, and it is possible that those who received the more advanced therapies were already on a recovery trajectory leading to better outcomes before the onset of the treatment. However, given control of initial level of disability and other key variables, the alternative hypothesis that advanced therapies contributed to better outcomes should be seriously entertained. The current findings add additional support to the alternative notion that use of therapy activities targeting functions at a higher level than the patient's current level of functioning may be associated with better outcomes.[24]

The total number of minutes spent in treatment contributed minimally to the prediction of outcomes. This finding calls into question a number of regulatory criteria for acute inpatient rehabilitation. For example, the Centers for Medicare and Medicaid Services requires that patients receive a minimum "dosage" of rehabilitation (e.g., 3-hours of treatment 5 days per week). Yet evidence that dosage of rehabilitation treatment has an impact on outcomes is sparse. A systematic review suggesting that the evidence is "strong" was based on four small sample studies (n=51 to 131) conducted in the 1990s in rehabilitation settings that significantly diverged from current practice in the United States.[34] Today, patients arrive to rehabilitation sooner post-injury and with greater medical complexity. They also leave more quickly. The current study and prior discipline-specific studies of therapy intensity suggest: (a) the components of treatment have a stronger impact on outcomes than total time, and (b) patient tolerance and preference in regard to intensity need to be taken into account.[25,35–38]

Results from the current study indicate that the level of effort a patient is able to expend in therapy is a critical predictor of rehabilitation outcomes, a finding that is corroborated by other recent studies.[39–41] Such findings may run contrary to practices that have become common since implementation of the 3-hour rule. For example, is a rigid practice of providing 3 hours of therapy each Monday through Friday a poor deployment of resources when a patient is experiencing agitation, pain, or other discomfort affecting effort? Would therapy time be better spent later in the stay when these conditions that detract from effort have resolved or are more easily tolerated? In contrast, attempts to assure compliance with the 3-hour rule necessitate therapists make up cancelled sessions at the end of the day, oftentimes when patients are more fatigued and unable to put forth their best effort. Is pushing an exhausted patient through the last 30 minutes needed to reach 3 hours that day the best use of therapeutic resources?

With limited evidence to inform the use of neuroactive medications during inpatient rehabilitation, rehabilitation professionals often wonder if such medications are hastening, hindering, or having no impact on short- and long-term outcomes.[42–45] Numerous positive associations were identified for the use of a variety of medication classes in the discharge outcome models. In fact, all significant medication classes were associated with positive outcomes at discharge. Despite these numerous positive associations with discharge outcomes, the only medication class to be associated with positive outcomes at discharge and 9-months post-discharge was narcotic analgesics, suggesting that the benefits of medications may wane over time and have little or no substantial influence on longer-term recovery. Furthermore, the negative associations of medications with outcomes at 9-months post-discharge suggest that certain classes of medications may actually be deleterious to long-term outcome following discharge from acute rehabilitation. Specifically, second generation antipsychotics, psychotherapeutics, and non-narcotic analgesics were negatively associated with 9-month post-discharge Cognitive status; and new SSRI antidepressants and non-narcotic analgesics were negatively associated with Motor function. Further research is warranted to determine if these negative findings are causative of worse outcomes—in which case they should be avoided during inpatient rehabilitation—or if the associations are simply markers of higher patient severity and consequent worse outcomes.

Limitations

Some limitations to the study should be noted. Although we collected comprehensive data on a large sample of TBI patients treated in brain injury rehabilitation units in geographically diverse parts of the country, there were data elements that we could not be collected due to not being present in available documentation. These variables included measures of acute hospital findings, home environment, caregiver characteristics, and socioeconomic factors. The extent to which these variables may affect our findings is unknown. The analyses reported here also did not examine various combinations of therapy activities and thus cannot speak to interactive effects and their potential impact on outcomes.

CONCLUSIONS

This article presents promising insights into therapy activities and medications that are associated with better outcomes. Greater patient level of effort during therapy sessions, time spent in more complex therapy activities, and use of specific medications were associated with better outcomes at discharge for patients in all admission FIM Cognitive subgroups. Further research is warranted to examine more specific combinations of therapy activities and medications that are associated with better outcomes. At 9-months post-discharge, the associations with inpatient therapies were less pronounced and pervasive, but some relationships were still evident. In contrast, positive associations that were observed between classes of medications used during inpatient rehabilitation were negatively associated with outcomes 9 months post-discharge.

Acknowledgments

Abbreviations

FIM	Functional Independence Measure
LOS	Length of stay
TBI	Traumatic brain injury
OT	Occupational therapy
PBE	Practice-Based Evidence
PT	Physical therapy
ST	Speech therapy
PSY	Psychology
TREC	Recreational therapy

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Appendix. Short and Long Definitions of All Included Covariates and Dependent Variables

Variable	Short definition	Long definition
Demographic characteristics		
AgeAtAdmission	Age	Age
GenderMale	Male	Male
RaceBlack	Race black	Race black
RaceWhite	Race white	Race white
RaceWhiteHispanic	Race white Hispanic	Race white Hispanic
RaceAsianOtherUnknown	Race Asian/other/unknown	Race Asian/other/unknown
EduTowardsHighSchool	Education: some high school, no diploma	Education: some high school, no diploma
PayerMedicaid	Payer Medicaid	Payer Medicaid
Pre-injury health information		
SubstanceUse	Substance use	Substance use
AvgBMIle18p5	Body Mass Index (BMI) <18.5	Body Mass Index (BMI) <18.5
Injury and rehabilitation stay characteristics		
ComposAnxietyYN	Anxiety	Anxiety
ComposDepressionYN	Depression	Depression
PcntAgitationOverStay	% of rehab stay agitated	% of rehab stay agitated
DaysInjuryToRehabAdm	Days from injury to rehab admission	Days from injury to rehab admission
PTAClearedPriorToAdmYN	PTA cleared prior to rehab admission	PTA cleared prior to rehab admission
Max2pBICSIc	Maximum brain injury component of CSI score	Maximum brain injury component of CSI score
Max2pRemainCSIc	Maximum non-brain injury component of CSI score	Maximum non-brain injury component of CSI score
Functional status characteristics		

Variable	Short definition	Long definition
AdmFIMRASCHMotor	Admission FIM Motor Rasch-transformed	Admission FIM Motor Rasch-transformed
AdmFIMRASCHCog	Admission FIM Cog Rasch-transformed	Admission FIM Cog Rasch-transformed
Treatment factors		
Total time		
OTTotalMinPWk0i	OT total min/week	OT total min/week
PTTotalMinPWk0i	PT total min/week	PT total min/week
SLPTotalMinPWk0i	ST total min/week	ST total min/week
PSYTotalMinPWk0i	PSY total min/week	PSY total min/week
TRECTotalMinPWk0i	TREC total min/week	TREC total min/week
Level of effort		
AverageOTPTSLPLOEOverStay	Average OT, PT, ST level of effort	Average OT, PT, ST level of effort
Occupational therapy		
OTActCastingMinPWkCol	OT casting min/week	OT casting min/week
OTActCogImpairmentMinPWkCol	OT cognitive impairment min/week	OT cognitive activity, perceptual activity, visual activity
OTActCommIADLsMinPWkCol	OT community IADLs min/week	OT pre-driving activity, community transport, pre-vocational/vocational, community mobility, community reintegration, lesiure performance
OTActEducationMinPWkCol	OT education min/week	OT education, sexuality
OTActEnvironAdapMinPWkCol	OT environmental adaption min/week	OT environmental adaption
OTActEvaluationMinPWkCol	OT evaluation min/week	OT initial evaluation, interview
OTActHomeIADLsMinPWkCol	OT home IADLs min/week	OT functional mobility, home/money/meal management
OTActPhysImpairmentMinPWkCol	OT physical impairments min/week	OT pre-functional activity, upper extremity activity
OTActWCManagementMinPWkCol	OT wheelchair management min/week	OT wheelchair management
OTAssessTotalMinMinPWkCol	OT assessment min/week	OT assessment
OTBedMobTransfPerCareBasCol	OT bed/chair/WC transfer, feeding, dressing (basic) min/week	OT bed mobility, transfers- basic (bed/chair/WC transfer), personal care- basic (feeding, upper/lower-body dressing, grooming)
OTPersonalCareTransfCol	OT personal care/transfers (advanced) min/week	OT personal care- advanced (bathing, toileting), transfers-advanced (toilet transfer, tub/shower transfer, car transfer)
Physical therapy		
PTAdvGaitGaitCommMobStrsCol	PT advanced locomotion min/week	PT advanced gait, gait, community mobility, stairs
PTEquipMngWCMobCastTranMovCol	PT equip management, transitional movements (basic) min/week	PT equipment management, wheelchair mobility, casting, transitional movements (developmental sequencing, bed mobility, sitting, transfers)
PTEvaluationAtPtHomeMinPWkCol	PT evaluation at patient home min/week	PT evaluation at patient home
PTFormalAssessMinPWkCol	PT formal assessment min/week	PT formal assessment
PTPreFunctActTheraExMinPWkCol	PT pre-functional activity and therapeutic exercise min/week	PT pre-functional activity and therapeutic exercise

Variable	Short definition	Long definition
PTPreGaitStandingMinPWkCol	PT pre-gait/standing min/week	PT pre-gait/standing minutes/week
PTPreparationTimeMinPWkCol	PT preparation time min/week	PT preparation time minutes/week
PTRestingMinPWkCol	PT resting min/week	PT resting minutes/week
Speech therapy		
SLPAssessmentsMinPWkCol	ST assessment min/week	ST cognition/language/speech assessment, hearing screening, JFK coma recovery scale, O-Log/GOAT, sensory stimulation, swallowing assessment: bed, FEES, and MBS
SLPAttentionBothMinPWkCol	ST attention (both) min/week	ST Auditory/verbal attention, cancellation tasks, left attention/visual scanning
SLPAuditoryComprAdvMinPWkCol	ST auditory comprehension (advanced) min/week	ST conversational level- auditory, following multi-step commands, sentence/paragraph comprehension
SLPAuditoryExprCol	ST auditory comprehension/expression (basic) min/week	ST auditory comprehension- basic (following 1-step commands, word matching, yes/no questions), expression- basic (automatic speech, defining words, describing objects, gesture use, naming, phrase production, sentence production)
SLPAugmentDevMinPWkCol	ST augmentation devices min/week	ST high/low-tech communication devices
SLPCommAccGamesCol	ST community access/games min/week	ST community access (community outings, simple/complex functional tasks, develop daily schedule, return to work/school, route finding), games
SLPComputerAppMinPWkCol	ST computer applications min/week	ST computer applications, specialized software
SLPEduMinPWkCol	ST education min/week	ST education
SLPExpressionAdvMinPWkCol	ST expression (advanced) min/week	ST circumlocution, conversational level- expression, multi- modal communication, multi-sentence production
SLPLipReadMinPWkCol	ST lip reading min/week	ST lip reading
SLPMotorSpeechBasicMinPWkCol	ST motor speech (basic) min/week	ST diaphragmatic breathing, oral/motor exercises, repetition abilities, speech intelligibility, vocal function exercises (phonation)
SLPPMVSpeakValveCorkMinPWkCol	ST PMV/speaking valve/cork min/week	ST PMV/speaking valve/cork
SLPProbSolvMathMoneyMemoryCol	ST problem solving, math/money, memory/orientation (advanced) min/week	ST problem solving/reasoning- advanced/basic (advanced: paper/pencil; basic: environmental, sequencing, verbal reasoning, functional hypotheses), math/money- advanced/basic (advanced: budgeting, counting, functional math/word problems, grade-specific math, time span calculations; basic: basic arithmetic), memory/orientation- advanced/basic (advanced: compensation strategies- internal, delayed recall; basic: compensation strategies- external, immediate recall, O-group, spaced

Variable	Short definition	Long definition
		retrieval, verbal orientation review, work/memory)
SLPReadWriteAdvMinPWkCol	ST reading/writing (advanced) min/week	ST analysis, functional reading (menu, med list, etc.), functional writing (cheques, forms, etc.), multi-paragraph, oral reading, paragraphs
SLPReadWriteBasicMinPWkCol	ST reading/writing (basic) min/week	ST copying, phrases, sentences, single words tracing
SLPSwallowMinPWkCol	ST swallowing min/week	ST meal observation/analysis, oral stimulation, P.O. trials, pre-swallowing, swallow strengthening exercises, swallowing strategies
Psychology		
PSYCogRemMinPWkCol	PSY cognitive remediation min/week	PSY cognitive remediation patient, family, and patient & family
PSYCrtBehavStffCnsltCrisIntCol	PSY total indirect min/week	PSY create a behavior plan, staff consultation, crisis intervention
PSYGenTBIEduMinPWkCol	PSY general TBI education min/week	PSY general TBI education patient, family, and patient & family
PSYInfoHxMinPWkCol	PSY information and history gathering min/week	PSY information and history gathering patient, family, and patient & family
PSYNeuroBehavTestPatTBIEduCol	PSY testing/assessment/behavioral min/week	PSY neuropsych testing, neurobehavioral assessment, patient-specific TBI education, psychotherapeutic and behavioral
Therapeutic recreation		
TRECActivityArtsBatchMinPWk0i	TREC art min/week	TREC self expression, cooking/baking, creative writing, crafts, dance/drama
TRECActivityCogActBatchMinPWk0i	TREC cognitive activity min/week	TREC puzzles, reading, observation, relaxation, computer: email/games, movie/performances, card games, board/table games, wii
TRECActivityMusicBatchMinPWk0i	TREC music min/week	TREC musical instruments, operating cd/mp3, music games
TRECActivitySportBatchMinPWk0i	TREC sports min/week	TREC billiards, basketball, soccer, volleyball, swimming, disc frisbee, weight room/gym, softball/baseball/football, bowling, active tabletop games, bowling, active tabletop games, biking/hand cycling, golf/putting/croquet, bocce ball
TRECCommunityReintMinPWk0i	TREC community reintegration min/week	TREC community reintegration
Medications		
PctSANALGESICSNARCOTIC	% of rehab stay on narcotic-analgesics	% of rehab stay on narcotic-analgesics
PctSANALGESICSNONNARCOTIC	% of rehab stay on nonnarcotic-analgesics	% of rehab stay on nonnarcotic-analgesics
PctSANTIANXIETYAGENTS	% of rehab stay on antianxiety agents	% of rehab stay on antianxiety agents
PctSANTICONVULSANT	% of rehab stay on anticonvulsants	% of rehab stay on anticonvulsants

Variable	Short definition	Long definition
PctSANTIDEPRESSANTSSSRInew	% of rehab stay on antidepressants- new SSRIs	% of rehab stay on antidepressants- new SSRIs
PctSANTIDEPRESSANTSother	% of rehab stay on antidepressants- other	% of rehab stay on antidepressants- other
PctSANTIPARKINSONIAN	% of rehab stay on antiparkinsonians	% of rehab stay on antiparkinsonians
PctSANTIPSYCHOTICSSecondgenat	% of rehab stay on antipsychotics- second generation	% of rehab stay on antipsychotics- second generation
PctSHYPNOTICS	% of rehab stay on hypnotics	% of rehab stay on hypnotics
PctSMISCPSYCHOTHERAPEUTIC	% of rehab stay on psychotherapeutics	% of rehab stay on psychotherapeutics
PctSSTIMULANTS	% of rehab stay on stimulants	% of rehab stay on stimulants
Site (removed)		
	Site 1	Site 1
	Site 2	Site 2
	Site 3	Site 3
	Site 4	Site 4
	Site 5	Site 5
	Site 6	Site 6
	Site 7	Site 7
	Site 8	Site 8
	Site 9	Site 9
	Site 10	Site 10
Outcomes		
CorrectedRehabLOS	Rehab length of stay excluding interruptions	Rehab length of stay excluding interruptions
DCLocationHome	Discharge destination- home	Discharge destination- home
DCFIMRASCHMotor	Discharge FIM Motor Rasch-transformed	Discharge FIM Motor Rasch-transformed
DCFIMRASCHCog	Discharge FIM Cog Rasch-transformed	Discharge FIM Cog Rasch-transformed
FIMRASCHMotor_9Mon	9-Month FIM Motor Rasch-transformed	9-Month FIM Motor Rasch-transformed
FIMRASCHCog_9Mon	9-Month FIM Cog Rasch-transformed	9-Month FIM Cog Rasch-transformed

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			Days	Days	Days	Days	Days
N used	338			366			481			382			400							
R^2 pat, inj + POC act + LOE + meds	0.374			0.483			0.55			0.548			0.589							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
Intercept	48.23	0	<.001	14.99	0	<.001	25.78	0	<.001	40.67	0	<.001	19.02	0	<.001	.	.	.	.	.
Demographics																				
Age	.	.	.	.	.	.	-0.07	-0.11	0.002	.	.	.	0.024	0.071	0.043	.	.	-3.12	.	1.11
Race black	.	.	.	.	.	.	.	.	.	.	.	.	1.877	0.091	0.007	.	.	.	.	0.30
Race white	.	.	.	.	.	.	.	.	.	-3.24	-0.12	0.001	.	.	.	.	.	.	-2.44	.
Payer Medicaid	6.616	0.098	0.03	3.861	0.087	0.027	.	.	.	.	.	.	.	.	.	1.39	0.72	.	.	.
Pre-injury health information																				
Body Mass Index (BMI) <18.5	.	.	.	.	.	.	.	.	.	3.079	0.077	0.032	.	.	.	.	.	.	0.28	.
Injury and rehabilitation stay characteristics																				
Anxiety	.	.	.	4.519	0.131	0.001	2.348	0.084	0.013	.	.	.	.	.	.	.	.	2.14	1.09	.
Depression	9.313	0.169	<.001	.	.	.	.	.	.	2.369	0.102	0.008	1.434	0.095	0.006	4.44	.	.	1.24	0.69
Days from injury to rehab admission	0.083	0.116	0.012	.	.	.	0.036	0.08	0.026	0.052	0.125	<.001	0.061	0.158	<.001	3.01	.	0.95	1.15	1.02
Maximum brain injury component of CSI score	.	.	.	0.25	0.239	<.001	0.072	0.081	0.039	0.142	0.165	<.001	0.111	0.151	<.001	.	16.73	3.68	5.20	2.58
Maximum non-brain injury component of CSI score	.	.	.	0.16	0.201	<.001	0.166	0.244	<.001	0.071	0.125	0.002	.	.	.	.	4.96	4.38	1.69	.
Functional status characteristics																				
Admission FIM Motor Rasch-transformed	-0.42	-0.22	<.001	.	.	.	-0.17	-0.17	<.001	-0.25	-0.26	<.001	-0.22	-0.31	<.001	-4.85	.	-5.57	#####	-9.69
Admission FIM Cog Rasch-transformed	.	.	.	.	.	.	.	.	.	-0.43	-0.09	0.017	.	.	.	.	.	.	#####	.
Treatment factors																				
Average OT, PT, ST level of effort	.	.	.	.	.	.	.	.	.	2.386	0.126	<.001	.	.	.	.	.	.	10.69	.
Occupational therapy																				
OT cognitive impairment min/week	.	.	.	.	.	.	0.017	0.071	0.04	.	.	.	.	.	.	.	.	.	1.25	.
OT education min/week	.	.	.	.	.	.	-0.12	-0.09	0.005	-0.08	-0.08	0.03	-0.03	-0.07	0.037	.	.	-0.77	-0.60	-0.30
OT evaluation min/week	.	.	.	-0.24	-0.12	0.004	.	.	.	.	.	.	.	.	.	-0.90	.	.	.	.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			Days	Days	Days	Days	Days
N used	338			366			481			382			400							
R^2 pat, inj + POC act + LOE + meds	0.374			0.483			0.55			0.548			0.589							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Days	Days	Days	Days	Days
OT physical impairments min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.016	0.151	<.001	.	.	.	.	1.19
OT assessment min/week	.	.	.	-0.19	-0.21	<.001	.	.	.	.	.	.	.	.	.	.	-3.34	.	.	.
OT bed/chair/WC transfer, feeding, dressing (basic) min/week	.	.	.	-0.04	-0.11	0.01	.	.	.	.	.	.	.	.	.	.	-2.50	.	.	.
OT personal care/transfers (advanced) min/week	.	.	.	0.116	0.135	0.001	.	.	.	.	.	.	.	.	.	.	2.81	.	.	.
Physical therapy																				
PT equip management, transitional movements (basic) min/week	.	.	.	.	.	.	-0.02	-0.09	0.022	.	.	.	.	.	.	.	.	-1.31	.	.
PT formal assessment min/week	-0.51	-0.23	<.001	.	.	.	-0.1	-0.14	<.001	-0.08	-0.14	<.001	-0.03	-0.13	<.001	-7.31	.	-2.51	-2.30	-1.23
PT preparation time min/week	.	.	.	.	.	.	0.208	0.13	<.001	.	.	.	.	.	.	.	.	1.46	.	.
PT resting min/week	.	.	.	.	.	.	.	.	.	-0.05	-0.1	0.006	.	.	.	.	.	.	-1.25	.
Speech therapy																				
ST assessment min/week	-0.12	-0.16	0.001	-0.1	-0.19	<.001	-0.08	-0.17	<.001	-0.09	-0.26	<.001	-0.03	-0.18	<.001	-4.28	-3.38	-3.18	-4.10	-1.63
ST community access/games min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.017	0.122	<.001	.	.	.	.	0.50
ST education min/week	-0.22	-0.1	0.044	-0.14	-0.1	0.017	-0.09	-0.09	0.01	.	.	.	.	.	.	-2.28	-1.75	-1.31	.	.
ST expression (advanced) min/week	0.299	0.132	0.006	.	.	.	0.135	0.136	<.001	.	.	.	0.08	0.137	<.001	2.44	.	1.33	.	0.47
ST motor speech (basic) min/week	.	.	.	.	.	.	0.1	0.081	0.018	.	.	.	.	.	.	.	.	0.38	.	.
ST reading/writing (advanced) min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.063	0.079	0.019	.	.	.	.	0.24
ST swallowing min/week	-0.09	-0.15	0.002	.	.	.	.	.	.	.	.	.	.	.	.	-4.36	.	.	.	.
Pyschology																				
PSY cognitive remediation min/week	0.141	0.156	<.001	.	.	.	.	.	.	.	.	.	.	.	.	0.89	.	.	.	.
PSY information and history gathering min/week	.	.	.	-0.3	-0.1	0.017	-0.11	-0.08	0.017	-0.19	-0.17	<.001	-0.07	-0.12	<.001	.	-1.04	-0.71	-1.48	-0.67

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			Days	Days	Days	Days	Days
N used	338			366			481			382			400							
R^2 pat, inj + POC act + LOE + meds	0.374			0.483			0.55			0.548			0.589							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Days	Days	Days	Days	Days
Therapeutic recreation																				
TREC art min/week	.	.	.	0.138	0.081	0.039	.	.	.	.	.	.	0.055	0.087	0.012	.	0.58	.	.	0.17
Medications																				
% of rehab stay on anticonvulsants	.	.	.	.	.	.	0.023	0.076	0.019	.	.	.	.	.	.	.	.	.	0.91	.
% of rehab stay on antiparkinsonians	.	.	.	.	.	.	0.046	0.113	<.001	.	.	.	.	.	.	.	.	.	0.78	.
% of rehab stay on antipsychotics- second generation	0.148	0.185	<.001	.	.	.	.	.	.	.	.	.	.	.	.	3.16	.	.	.	.
% of rehab stay on stimulants	.	.	.	0.053	0.123	0.002	.	.	.	.	.	.	.	.	.	.	1.65	.	.	.

<-0.5 days	(red)
-0.5 to 0 days	(orange)
>0-0.5 days	(light green)
>0.5 days	(dark green)

Figure 1.

Ordinary Least Squares Regression Models Predicting Rehabilitation Length of Stay by Admission FIM Cognitive Score.

Footnote. Red values indicate a negative association (coefficient), while green indicates a positive one. Dark green and red values indicate >+0.5 days or <−0.5 days, respectively. Light green and red values indicate +0.5 to 0 days or −0.5 to 0 days, respectively.

Abbreviations: FIM, Functional Independence Measure; LOE, level of effort; CSI,

Comprehensive Severity Index; PTA, post traumatic amnesia; OT, occupational therapy; PSY, psychology; PT, physical therapy; ST, speech therapy; TREC, therapeutic recreation.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			Effect	Effect	Effect	Effect	Effect
N used	339			373			493			407			502							
c-Statistic pat, inj + POC act + LOE + meds	0.906			0.865			0.845			0.84			0.779							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
Intercept	-1.4	_	0.109	-0.73	_	0.453	-0.27	_	0.815	0.742	_	0.543	6.128	_	<.001	.	.	.	.	.
Demographics																				
Age	-0.03	-0.39	<.001	-0.05	-0.55	<.001	-0.04	-0.5	<.001	-0.04	-0.45	<.001	-0.03	-0.37	<.001	-1.40	-2.12	-1.86	-1.76	-1.44
Pre-injury health information																				
Substance use	.	.	.	.	.	.	.	.	.	.	.	.	-1.13	-0.31	0.006	.	.	.	.	-0.54
Injury and rehabilitation stay characteristics																				
Anxiety	.	.	.	.	.	.	.	.	.	-0.81	-0.22	0.015	.	.	.	.	.	.	.	-0.34
Maximum brain injury component of CSI score	.	.	.	.	.	.	.	.	.	-0.04	-0.25	0.013	.	.	.	.	.	.	.	-0.98
Maximum non-brain injury component of CSI score	.	.	.	-0.02	-0.18	0.032	.	.	.	.	.	.	.	.	.	.	-0.45	.	.	.
Treatment factors																				
Average OT, PT, ST level of effort	0.99	0.422	<.001	1.092	0.437	<.001	0.753	0.257	0.004	0.601	0.209	0.013	.	.	.	3.23	4.06	3.13	2.69	.
Occupational therapy																				
OT education min/week	0.106	0.55	<.001	0.085	0.336	0.009	0.061	0.373	0.009	.	.	.	.	.	.	0.56	0.39	0.40	.	.
OT home IADLs min/week	0.059	0.593	<.001	.	.	.	.	.	.	.	.	.	.	.	.	0.96	.	.	.	.
OT assessment min/week	-0.04	-0.32	0.008	.	.	.	.	.	.	.	.	.	.	.	.	-0.57	.	.	.	.
OT bed/chair/WC transfer, feeding, dressing (basic) min/week	.	.	.	.	.	.	.	.	.	-0.01	-0.24	0.01	.	.	.	.	.	.	.	-0.35
OT personal care/transfers (advanced) min/week	0.017	0.216	0.038	.	.	.	.	.	.	.	.	.	.	.	.	0.41	.	.	.	.
Physical therapy																				
PT advanced locomotion min/week	.	.	.	.	.	.	0.01	0.413	<.001	.	.	.	.	.	.	.	.	.	1.05	.
PT equip management, transitional movements (basic) min/week	.	.	.	.	.	.	.	.	.	-0.01	-0.25	0.004	.	.	.	.	.	.	.	-0.40
PT formal assessment min/week	.	.	.	.	.	.	.	.	.	0.029	0.319	0.006	.	.	.	.	.	.	.	0.83

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			Effect	Effect	Effect	Effect	Effect
N used	339			373			493			407			502							
c-Statistic pat, inj + POC act + LOE + meds	0.906			0.865			0.845			0.84			0.779							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
PT pre-functional activity and therapeutic exercise min/week	.	.	.	.	.	.	.	.	.	-0.01	-0.22	0.015	.	.	.	.	.	.	.	-0.58
PT pre-gait/standing min/week	-0.03	-0.35	<.001	.	.	.	-0.02	-0.27	0.002	.	.	.	.	.	.	-0.91	.	-0.57	.	.
PT preparation time min/week	.	.	.	.	.	.	.	.	.	0.05	0.229	0.038	.	.	.	.	.	.	0.32	.
Speech therapy																				
ST auditory comprehension (advanced) min/week	.	.	.	0.058	0.257	0.037	.	.	.	0.051	0.328	0.02	.	.	.	.	0.30	.	0.27	.
ST education min/week	0.167	1.126	<.001	0.037	0.251	0.014	0.058	0.46	<.001	0.036	0.299	0.01	0.051	0.473	0.007	1.75	0.46	0.87	0.52	0.62
ST motor speech (basic) min/week	.	.	.	-0.03	-0.19	0.025	-0.02	-0.15	0.028	.	.	.	.	.	.	.	-0.15	-0.09	.	.
ST swallowing min/week	-0.01	-0.22	0.042	.	.	.	.	.	.	.	.	.	.	.	.	-0.43	.	.	.	.
Psychology																				
PSY information and history gathering min/week	.	.	.	.	.	.	.	.	.	-0.03	-0.18	0.03	.	.	.	.	.	.	.	-0.20
Therapeutic recreation																				
TREC sports min/week	.	.	.	.	.	.	.	.	.	-0.03	-0.22	0.012	.	.	.	.	.	.	.	-0.12
Medications																				
% of rehab stay on antidepressants- new SSRIs	.	.	.	0.017	0.272	0.004	.	.	.	.	.	.	.	.	.	.	0.20	.	.	.
% of rehab stay on hypnotics	.	.	.	.	.	.	.	.	.	0.016	0.271	0.025	.	.	.	.	.	.	.	0.23

<-1 effect
-1 to 0 effect
>0-1 effect
>1 effect

Figure 2.

Logistic Regression Models Predicting Discharge Destination Home by Admission FIM Cognitive Score.

Footnote. Effect equals the predictor's effect on the logit (exponential function) of the regression coefficient. Red values indicate a negative association (coefficient), while green indicates a positive one. Dark green and red values indicate >+1 effect or <−1 effect, respectively. Light green and red values indicate +1 to 0 effect or −1 to 0 effect, respectively. Abbreviations: FIM, Functional Independence Measure; LOE, level of effort; CSI, Comprehensive Severity Index; PTA, post traumatic amnesia; OT, occupational therapy; PSY, psychology; PT, physical therapy; ST, speech therapy; TREC, therapeutic recreation.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21							
N used	339			373			493			407			502							
R^2 pat, inj + POC act + LOE + meds	0.739			0.699			0.626			0.626			0.764							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	FIM points	FIM points	FIM points	FIM points	FIM points
Intercept	19.05	0	<.001	34.32	0	<.001	34.28	0	<.001	23.32	0	<.001	35.45	0	<.001	.	.	.	.	.
Demographics																				
Age	-0.1	-0.13	<.001	-0.09	-0.13	<.001	-0.08	-0.14	<.001	-0.08	-0.13	<.001	-0.09	-0.12	<.001	-4.42	-3.71	-3.63	-3.69	-4.00
Race black	.	.	.	.	.	.	.	.	.	.	.	.	-2.99	-0.07	0.003	.	.	.	.	-0.42
Pre-injury health information																				
Substance use	.	.	.	.	.	.	2.332	0.092	0.002	.	.	.	.	.	.	.	.	1.21	.	.
Injury and rehabilitation stay characteristics																				
Days from injury to rehab admission	-0.09	-0.19	<.001	-0.07	-0.18	<.001	-0.04	-0.1	0.002	.	.	.	.	.	.	-3.08	-2.21	-1.02	.	.
% of rehab stay agitated	.	.	.	.	.	.	0.086	0.122	<.001	0.079	0.078	0.017	.	.	.	.	.	0.73	0.32	.
Maximum non-brain injury component of CSI score	-0.05	-0.07	0.025	.	.	.	-0.08	-0.13	<.001	.	.	.	.	.	.	-1.53	.	-2.00	.	.
Functional status characteristics																				
Admission FIM Motor Rasch-transformed	0.104	0.086	0.012	0.134	0.161	<.001	0.184	0.216	<.001	0.541	0.513	<.001	0.721	0.709	<.001	1.20	3.11	6.28	21.88	34.81
Treatment factors																				
Average OT, PT, ST level of effort	8.683	0.384	<.001	4.997	0.265	<.001	5.56	0.273	<.001	3.924	0.189	<.001	.	.	.	28.33	18.58	23.14	17.57	.
Occupational therapy																				
OT casting min/week	-0.13	-0.12	<.001	-0.17	-0.11	<.001	.	.	.	.	.	.	.	.	.	-0.78	-0.55	.	.	.
OT cognitive impairment min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.027	0.115	<.001	.	.	.	.	1.72
OT community IADLs min/week	.	.	.	0.056	0.099	0.002	.	.	.	0.034	0.066	0.042	.	.	.	.	0.81	.	0.52	.
OT home IADLs min/week	0.156	0.162	<.001	.	.	.	0.033	0.066	0.028	.	.	.	.	.	.	2.53	.	0.95	.	.
OT physical impairments min/week	-0.05	-0.15	<.001	-0.05	-0.18	<.001	-0.03	-0.11	<.001	-0.02	-0.08	0.02	.	.	.	-3.64	-3.17	-1.70	-1.16	.
OT assessment min/week	-0.09	-0.08	0.012	.	.	.	.	.	.	.	.	.	.	.	.	-1.29	.	.	.	.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	339			373			493			407			502							
R^2 pat, inj + POC act + LOE + meds	0.739			0.699			0.626			0.626			0.764							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
OT bed/chair/WC transfer, feeding, dressing (basic) min/week	.	.	.	-0.02	-0.08	0.024	.	.	.	.	.	.	-0.03	-0.08	0.009	.	-1.38	.	.	-0.98
OT personal care/transfers (advanced) min/week	0.083	0.106	<.001	.	.	.	.	.	.	.	.	.	.	.	.	1.96	.	.	.	.
Physical therapy																				
PT advanced locomotion min/week	0.029	0.138	<.001	0.022	0.131	<.001	.	.	.	.	.	.	.	.	.	3.05	2.36	.	.	.
PT equip management, transitional movements (basic) min/week	.	.	.	-0.04	-0.19	<.001	-0.05	-0.25	<.001	-0.07	-0.26	<.001	-0.03	-0.1	<.001	.	-3.10	-3.17	-3.05	-1.07
PT pre-functional activity and therapeutic exercise min/week	.	.	.	.	.	.	0.02	0.068	0.022	.	.	.	.	.	.	.	.	1.14	.	.
PT preparation time min/week	.	.	.	.	.	.	-0.12	-0.08	0.005	.	.	.	.	.	.	.	.	-0.83	.	.
Speech therapy																				
ST assessment min/week	.	.	.	-0.03	-0.06	0.047	.	.	.	.	.	.	-0.03	-0.07	0.002	.	-0.93	.	.	-1.19
ST auditory comprehension (advanced) min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.127	0.067	0.003	.	.	.	.	0.42
ST community access/games min/week	.	.	.	.	.	.	.	.	.	.	.	.	-0.02	-0.07	0.003	.	.	.	.	-0.51
ST motor speech (basic) min/week	-0.08	-0.07	0.043	.	.	.	-0.13	-0.12	<.001	.	.	.	.	.	.	-0.51	.	-0.49	.	.
ST problem solving, math/money, memory/orientation (advanced) min/week	0.054	0.155	<.001	0.031	0.134	<.001	.	.	.	0.016	0.075	0.02	.	.	.	3.43	2.80	.	1.29	.
ST reading/writing (basic) min/week	.	.	.	0.19	0.107	<.001	.	.	.	.	.	.	.	.	.	.	0.74	.	.	.
Psychology																				

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	339			373			493			407			502							
R^2 pat, inj + POC act + LOE + meds	0.739			0.699			0.626			0.626			0.764							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
PSY total indirect min/week	-0.14	-0.06	0.028	.	.	.	.	.	.	.	.	.	.	.	.	-0.20	.	.	.	.
PSY information and history gathering min/week	.	.	.	.	.	.	.	.	.	.	.	.	-0.08	-0.07	0.003	.	.	.	.	-0.65
PSY testing/assessment/behavioral min/week	.	.	.	0.029	0.104	0.002	.	.	.	.	.	.	.	.	.	.	1.30	.	.	.
Therapeutic recreation																				
TREC cognitive activity min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.023	0.053	0.026	.	.	.	.	0.43
Medications																				
% of rehab stay on narcotic-analgesics	.	.	.	.	.	.	.	.	.	0.023	0.076	0.021	.	.	.	.	.	.	1.22	.
% of rehab stay on nonnarcotic-analgesics	.	.	.	0.032	0.09	0.005	0.021	0.061	0.044	.	.	.	.	.	.	.	1.09	0.72	.	.
% of rehab stay on antianxiety agents	.	.	.	0.026	0.071	0.021	0.023	0.062	0.033	.	.	.	.	.	.	.	0.62	0.42	.	.
% of rehab stay on antiparkinsonians	.	.	.	.	.	.	.	.	.	0.046	0.096	0.003	.	.	.	.	.	.	0.49	.
% of rehab stay on antipsychotics- second generation	0.035	0.068	0.026	.	.	.	.	.	.	.	.	.	.	.	.	0.74	.	.	.	.
% of rehab stay on hypnotics	.	.	.	.	.	.	.	.	.	.	.	.	0.026	0.052	0.021	.	.	.	.	0.38

<-0.5 FIM points
-0.5 to 0 FIM points
>0-0.5 FIM points
>0.5 FIM points

Figure 3.

Ordinary Least Squares Regression Models Predicting Rasch-Transformed Discharge FIM Motor Score by Admission FIM Cognitive Score.

Footnote. Red values indicate a negative association (coefficient), while green indicates a positive one. Dark green and red values indicate >+0.5 FIM points or <−0.5 FIM points, respectively. Light green and red values indicate +0.5 to 0 FIM points or −0.5 to 0 FIM points, respectively. Abbre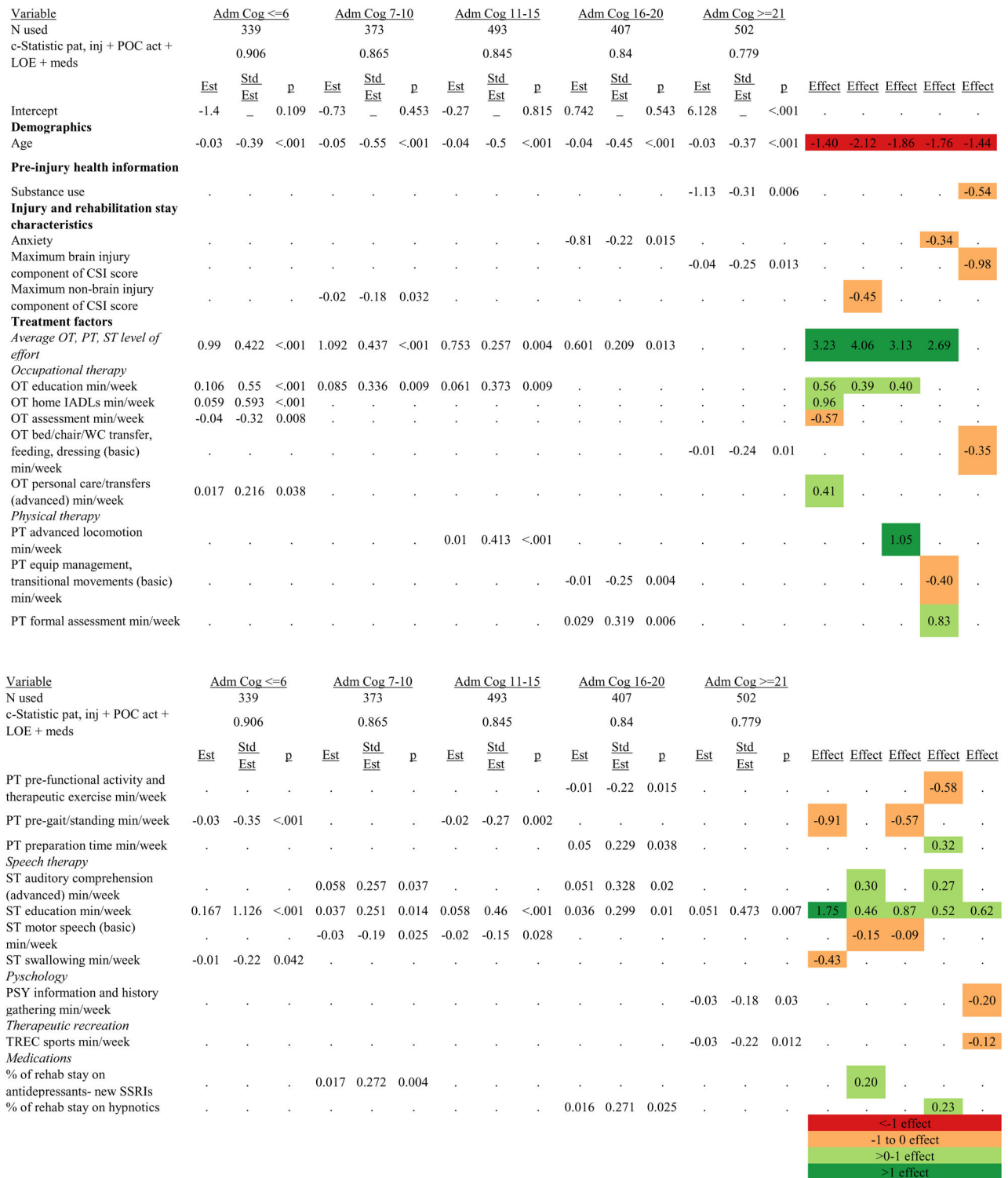viations: FIM, Functional Independence Measure; LOE, level of effort; CSI, Comprehensive Severity Index; PTA, post traumatic amnesia; OT, occupational therapy; PSY, psychology; PT, physical therapy; ST, speech therapy; TREC, therapeutic recreation.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	339			373			493			407			502							
R^2 pat, inj + POC act + LOE + meds	0.639			0.518			0.395			0.301			0.501							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
Intercept	-8.25	0	0.016	15.73	0	<.001	22.26	0	<.001	15.17	0	0.036	15.74	0	<.001	.	.	.	.	.
Demographics																				
Age	.	.	.	.	.	.	-0.07	-0.15	<.001	.	.	.	-0.07	-0.14	<.001	.	.	-2.85	.	-3.36
Male	.	.	.	.	.	.	.	.	.	.	.	.	-1.88	-0.08	0.016	.	.	.	.	-1.27
Race white	.	.	.	.	.	.	.	.	.	.	.	.	2.759	0.109	0.001	.	.	.	.	2.03
Injury and rehabilitation stay characteristics																				
Anxiety	6.137	0.16	<.001	.	.	.	.	.	.	1.763	0.102	0.017	.	.	.	1.99	.	.	0.73	.
Days from injury to rehab admission	-0.05	-0.11	0.002	-0.04	-0.13	0.001	.	.	.	.	.	.	.	.	.	-1.88	-1.25	.	.	.
Maximum brain injury component of CSI score	.	.	.	.	.	.	-0.05	-0.09	0.05	.	.	.	-0.12	-0.11	0.006	.	.	-2.74	.	-2.52
Functional status characteristics																				
Admission FIM Motor Rasch-transformed	.	.	.	.	.	.	-0.21	-0.33	<.001	.	.	.	.	.	.	.	.	-7.22	.	.
Admission FIM Cog Rasch-transformed	.	.	.	.	.	.	0.433	0.135	<.001	0.332	0.095	0.031	0.636	0.437	<.001	.	.	16.66	15.75	37.90
Treatment factors																				
Average OT, PT, ST level of effort	11.27	0.483	<.001	8.574	0.586	<.001	6.99	0.458	<.001	5.637	0.417	<.001	4.027	0.243	<.001	36.76	31.88	29.09	25.24	19.81
Occupational therapy																				
OT personal care/transfers (advanced) min/week	0.109	0.136	<.001	.	.	.	.	.	.	.	.	.	.	.	.	2.57	.	.	.	.
Physical therapy																				
PT equip management, transitional movements (basic) min/week	.	.	.	.	.	.	-0.03	-0.17	<.001	.	.	.	0.02	0.086	0.016	.	.	-1.66	.	0.65
PT pre-functional activity and therapeutic exercise min/week	.	.	.	-0.02	-0.08	0.049	.	.	.	.	.	.	0.014	0.071	0.033	.	-1.20	.	.	1.06

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21							
N used	339			373			493			407			502							
R^2 pat, inj + POC act + LOE + meds	0.639			0.518			0.395			0.301			0.501							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	FIM points	FIM points	FIM points	FIM points	FIM points
PT pre-gait/standing min/week	.	.	.	.	.	.	.	.	.	-0.04	-0.13	0.004	.	.	.	.	.	.	-1.02	.
Speech therapy																				
ST assessment min/week	0.041	0.081	0.024	.	.	.	0.032	0.107	0.006	0.036	0.135	0.002	.	.	.	1.45	.	1.33	1.52	.
ST attention (both) min/week	.	.	.	.	.	.	-0.09	-0.13	<.001	.	.	.	.	.	.	.	.	-0.69	.	.
ST auditory comprehension (advanced) min/week	.	.	.	.	.	.	0.089	0.088	0.025	.	.	.	.	.	.	.	.	0.51	.	.
ST auditory comprehension/expression (basic) min/week	-0.03	-0.07	0.043	-0.05	-0.21	<.001	-0.09	-0.21	<.001	-0.07	-0.18	<.001	.	.	.	-1.39	-1.70	-1.18	-0.69	.
ST community access/games min/week	.	.	.	-0.03	-0.16	<.001	.	.	.	.	.	.	-0.02	-0.11	0.002	.	-1.37	.	.	-0.58
ST education min/week	.	.	.	.	.	.	.	.	.	.	.	.	-0.07	-0.1	0.004	.	.	.	.	-0.81
ST expression (advanced) min/week	0.193	0.13	<.001	.	.	.	.	.	.	.	.	.	.	.	.	1.57	.	.	.	.
ST motor speech (basic) min/week	.	.	.	.	.	.	-0.13	-0.16	<.001	.	.	.	.	.	.	.	.	-0.50	.	.
ST problem solving, math/money, memory/orientation (advanced) min/week	0.071	0.197	<.001	0.018	0.097	0.017	.	.	.	.	.	.	.	.	.	4.48	1.57	.	.	.
ST reading/writing (advanced) min/week	0.31	0.075	0.039	0.263	0.132	<.001	.	.	.	.	.	.	.	.	.	0.56	0.63	.	.	.
Psychology																				
PSY total indirect min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.113	0.065	0.045	.	.	.	.	0.10
PSY general TBI education min/week	.	.	.	.	.	.	-0.04	-0.09	0.026	.	.	.	.	.	.	.	.	-0.46	.	.
PSY testing/assessment/behavioral min/week	.	.	.	0.026	0.121	0.009	.	.	.	.	.	.	.	.	.	.	1.18	.	.	.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21							
N used	339			373			493			407			502							
R^2 pat, inj + POC act + LOE + meds	0.639			0.518			0.395			0.301			0.501							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	FIM points	FIM points	FIM points	FIM points	FIM points
Therapeutic recreation																				
TREC cognitive activity min/week	0.082	0.111	0.002	.	.	.	-0.02	-0.08	0.032	.	.	.	-0.02	-0.07	0.033	1.34	.	-0.58	.	-0.41
Medications																				
% of rehab stay on nonnarcotic-analgesics	.	.	.	.	.	.	.	.	.	0.03	0.135	0.002	.	.	.	.	.	.	1.18	.
% of rehab stay on antiparkinsonians	.	.	.	0.025	0.094	0.013	.	.	.	.	.	.	.	.	.	.	0.71	.	.	.
% of rehab stay on antipsychotics- second generation	0.044	0.084	0.014	.	.	.	0.03	0.115	0.003	.	.	.	.	.	.	0.94	.	0.57	.	.
% of rehab stay on hypnotics	.	.	.	.	.	.	0.025	0.09	0.016	.	.	.	.	.	.	.	.	0.47	.	.
% of rehab stay on stimulants	.	.	.	0.026	0.096	0.012	.	.	.	.	.	.	.	.	.	.	0.79	.	.	.

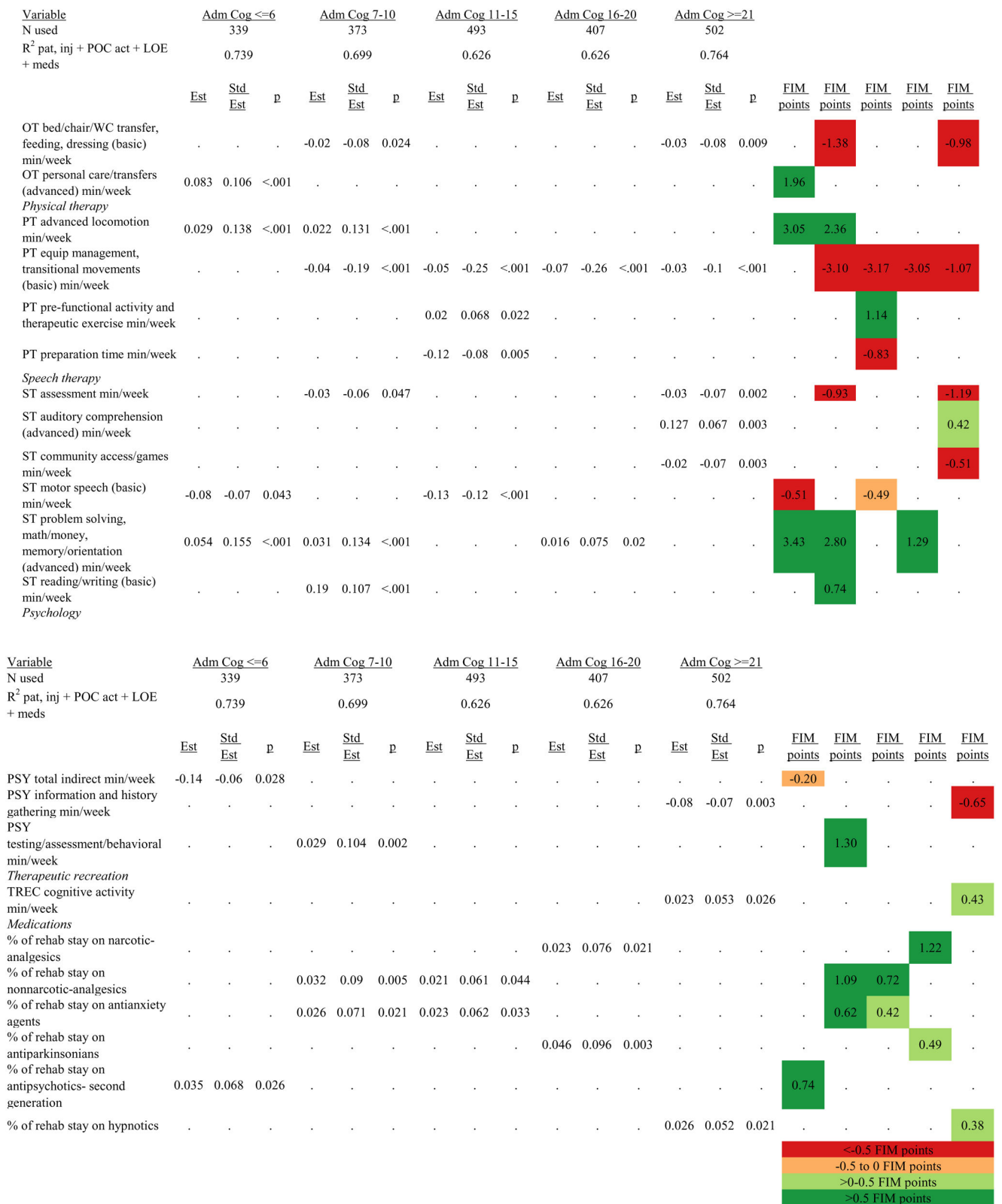| |
|---|
| <-0.5 FIM points |
| -0.5 to 0 FIM points |
| >0-0.5 FIM points |
| >0.5 FIM points |

Figure 4.

Ordinary Least Squares Regression Models Predicting Rasch-Transformed Discharge FIM Cognitive Score by Admission FIM Cognitive Score

Footnote. Red values indicate a negative association (coefficient), while green indicates a positive one. Dark green and red values indicate >+0.5 FIM points or <−0.5 FIM points, respectively. Light green and red values indicate +0.5 to 0 FIM points or −0.5 to 0 FIM

points, respectively. Abbreviations: FIM, Functional Independence Measure; LOE, level of effort; CSI, Comprehensive Severity Index; PTA, post traumatic amnesia; OT, occupational therapy; PSY, psychology; PT, physical therapy; ST, speech therapy; TREC, therapeutic recreation.

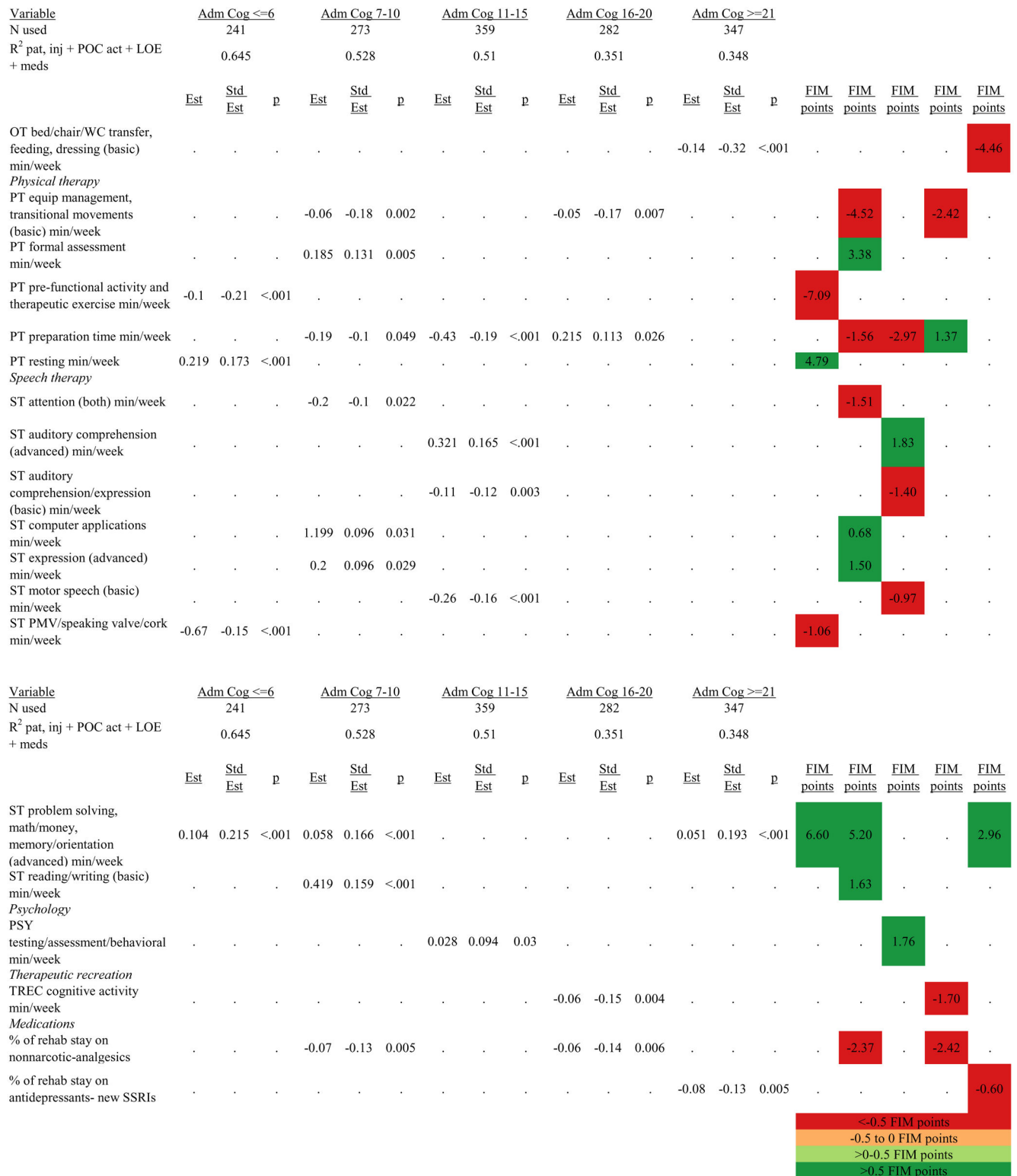| Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	241			273			359			282			347							
R^2 pat, inj + POC act + LOE + meds	0.645			0.528			0.51			0.351			0.348							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
Intercept	81.19	0	<.001	99.18	0	<.001	92.05	0	<.001	71.35	0	<.001	96.72	0	<.001	.	.	.	.	.
Demographics																				
Age	-0.46	-0.37	<.001	-0.3	-0.28	<.001	-0.32	-0.35	<.001	-0.25	-0.31	<.001	-0.2	-0.26	<.001	-19.59	-12.77	-13.85	-11.51	-9.11
Male	.	.	.	.	.	.	.	.	.	4.957	0.135	0.008	3.751	0.108	0.02	.	.	.	3.54	2.54
Race black	.	.	.	-6.58	-0.11	0.019	.	.	.	.	.	.	-6.18	-0.12	0.009	.	-0.92	.	.	-0.86
Race white	.	.	.	.	.	.	.	.	.	6.622	0.166	0.001	.	.	.	.	.	.	4.92	.
Education: some high school, no diploma	.	.	.	.	.	.	-4.3	-0.1	0.016	.	.	.	.	.	.	.	.	-1.08	.	.
Payer Medicaid	-6.01	-0.1	0.017	.	.	.	-4.41	-0.08	0.038	-7.63	-0.18	<.001	.	.	.	-1.26	.	-0.72	-1.31	.
Injury and rehabilitation stay characteristics																				
Anxiety	8.267	0.153	<.001	.	.	.	-4.24	-0.11	0.006	.	.	.	.	.	.	2.68	.	-1.92	.	.
Depression	.	.	.	-3.98	-0.1	0.028	.	.	.	.	.	.	-3.2	-0.1	0.038	.	-2.11	.	.	-1.31
Days from injury to rehab admission	-0.13	-0.21	<.001	-0.14	-0.28	<.001	-0.1	-0.19	<.001	-0.1	-0.21	<.001	-0.11	-0.2	<.001	-4.77	-4.85	-2.86	-2.64	-2.73
PTA cleared prior to rehab admission	.	.	.	.	.	.	.	.	.	-6.24	-0.18	<.001	.	.	.	.	.	.	-3.90	.
Maximum non-brain injury component of CSI score	.	.	.	.	.	.	-0.16	-0.17	<.001	.	.	.	.	.	.	.	.	.	-4.05	.
Admission FIM Motor Rasch-transformed	.	.	.	.	.	.	.	.	.	0.204	0.157	0.01	.	.	.	.	.	.	8.25	.
Treatment factors																				
Average OT, PT, ST level of effort	6.145	0.187	<.001	.	.	.	4.678	0.153	<.001	4.208	0.156	0.003	.	.	.	20.05	.	19.47	18.84	.
Occupational therapy																				
OT casting min/week	-0.26	-0.14	0.002	.	.	.	.	.	.	.	.	.	.	.	.	-1.64	.	.	.	.
OT cognitive impairment min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.026	0.103	0.028	.	.	.	.	1.61
OT physical impairments min/week	-0.1	-0.25	<.001	-0.06	-0.15	0.004	-0.06	-0.15	<.001	.	.	.	.	.	.	-8.03	-3.89	-3.30	.	.
OT wheelchair management min/week	-0.41	-0.09	0.035	.	.	.	.	.	.	.	.	.	.	.	.	-0.91	.	.	.	.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	241			273			359			282			347							
R² pat, inj + POC act + LOE + meds	0.645			0.528			0.51			0.351			0.348							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
OT bed/chair/WC transfer, feeding, dressing (basic) min/week	.	.	.	.	.	.	.	.	.	-0.14	-0.32	<.001	.	.	.	.	.	.	.	-4.46
Physical therapy																				
PT equip management, transitional movements (basic) min/week	.	.	.	-0.06	-0.18	0.002	.	.	.	-0.05	-0.17	0.007	.	.	.	.	-4.52	.	-2.42	.
PT formal assessment min/week	.	.	.	0.185	0.131	0.005	.	.	.	.	.	.	.	.	.	.	3.38	.	.	.
PT pre-functional activity and therapeutic exercise min/week	-0.1	-0.21	<.001	.	.	.	.	.	.	.	.	.	.	.	.	-7.09	.	.	.	.
PT preparation time min/week	.	.	.	-0.19	-0.1	0.049	-0.43	-0.19	<.001	0.215	0.113	0.026	.	.	.	.	-1.56	-2.97	1.37	.
PT resting min/week	0.219	0.173	<.001	.	.	.	.	.	.	.	.	.	.	.	.	4.79	.	.	.	.
Speech therapy																				
ST attention (both) min/week	.	.	.	-0.2	-0.1	0.022	.	.	.	.	.	.	.	.	.	.	-1.51	.	.	.
ST auditory comprehension (advanced) min/week	.	.	.	.	.	.	0.321	0.165	<.001	.	.	.	.	.	.	.	.	1.83	.	.
ST auditory comprehension/expression (basic) min/week	.	.	.	.	.	.	-0.11	-0.12	0.003	.	.	.	.	.	.	.	.	-1.40	.	.
ST computer applications min/week	.	.	.	1.199	0.096	0.031	.	.	.	.	.	.	.	.	.	.	0.68	.	.	.
ST expression (advanced) min/week	.	.	.	0.2	0.096	0.029	.	.	.	.	.	.	.	.	.	.	1.50	.	.	.
ST motor speech (basic) min/week	.	.	.	.	.	.	-0.26	-0.16	<.001	.	.	.	.	.	.	.	.	-0.97	.	.
ST PMV/speaking valve/cork min/week	-0.67	-0.15	<.001	.	.	.	.	.	.	.	.	.	.	.	.	-1.06	.	.	.	.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	241			273			359			282			347							
R² pat, inj + POC act + LOE + meds	0.645			0.528			0.51			0.351			0.348							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
ST problem solving, math/money, memory/orientation (advanced) min/week	0.104	0.215	<.001	0.058	0.166	<.001	.	.	.	.	.	.	0.051	0.193	<.001	6.60	5.20	.	.	2.96
ST reading/writing (basic) min/week	.	.	.	0.419	0.159	<.001	.	.	.	.	.	.	.	.	.	.	1.63	.	.	.
Psychology																				
PSY testing/assessment/behavioral min/week	.	.	.	.	.	.	0.028	0.094	0.03	.	.	.	.	.	.	.	.	1.76	.	.
Therapeutic recreation																				
TREC cognitive activity min/week	.	.	.	.	.	.	.	.	.	-0.06	-0.15	0.004	.	.	.	.	.	.	-1.70	.
Medications																				
% of rehab stay on nonnarcotic-analgesics	.	.	.	-0.07	-0.13	0.005	.	.	.	-0.06	-0.14	0.006	.	.	.	.	-2.37	.	-2.42	.
% of rehab stay on antidepressants- new SSRIs	.	.	.	.	.	.	.	.	.	-0.08	-0.13	0.005	.	.	.	.	.	.	.	-0.60

Legend:
- <-0.5 FIM points
- -0.5 to 0 FIM points
- >0-0.5 FIM points
- >0.5 FIM points

Figure 5.

Ordinary Least Squares Regression Models Predicting Rasch-Transformed 9-Month FIM Motor Score by Admission FIM Cognitive Score

Footnote. Red values indicate a negative association (coefficient), while green indicates a positive one. Dark green and red values indicate >+0.5 FIM points or <−0.5 FIM points, respectively. Light green and red values indicate +0.5 to 0 FIM points or −0.5 to 0 FIM points, respectively. Abbreviations: FIM, Functional Independence Measure; LOE, level of effort; CSI, Comprehensive Severity Index; PTA, post traumatic amnesia; OT, occupational therapy; PSY, psychology; PT, physical therapy; ST, speech therapy; PMV, Passy-Muir valve; TREC, therapeutic recreation.

Variable	Adm Cog <=6			Adm Cog 7-10			Adm Cog 11-15			Adm Cog 16-20			Adm Cog >=21			FIM points	FIM points	FIM points	FIM points	FIM points
N used	246			275			363			284			356							
R^2 pat, inj + POC act + LOE + meds	0.356			0.339			0.097			0.203			0.153							
	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p	Est	Std Est	p					
Intercept	46.68	0	<.001	91.62	0	<.001	86.96	0	<.001	66.13	0	<.001	41.45	0	<.001	.	.	.	.	.
Demographics																				
Age	-0.24	-0.24	<.001	-0.31	-0.32	<.001	-0.16	-0.2	<.001	.	.	.	.	.	.	-10.23	-13.10	-6.98	.	.
Race white	-5.58	-0.11	0.041	.	.	.	.	.	.	.	.	.	.	.	.	-4.34	.	.	.	.
Education: some high school, no diploma	.	.	.	-5.32	-0.12	0.018	-4.16	-0.11	0.035	-5.31	-0.15	0.007	.	.	.	.	-1.38	-1.04	-1.42	.
Injury and rehabilitation stay characteristics																				
Anxiety	.	.	.	-3.87	-0.1	0.046	-3.46	-0.11	0.039	.	.	.	-4.26	-0.14	0.007	.	-1.80	-1.57	.	-1.60
Days from injury to rehab admission	-0.07	-0.13	0.024	-0.08	-0.18	0.001	-0.06	-0.12	0.023	-0.05	-0.11	0.046	.	.	.	-2.66	-2.82	-1.63	-1.35	.
Functional status characteristics																				
Admission FIM Motor Rasch-transformed	.	.	.	-0.17	-0.15	0.01	.	.	.	.	.	.	.	.	.	.	-3.96	.	.	.
Admission FIM Cog Rasch-transformed	.	.	.	.	.	.	.	.	.	.	.	.	0.361	0.194	<.001	.	.	.	.	21.54
Treatment factors																				
Average OT, PT, ST level of effort	8.933	0.332	<.001	.	.	.	.	.	.	3.481	0.139	0.012	3.07	0.139	0.009	29.15	.	.	15.59	15.10
Occupational therapy																				
OT education min/week	0.465	0.176	0.001	.	.	.	.	.	.	.	.	.	.	.	.	2.45	.	.	.	.
Physical therapy																				
PT equip management, transitional movements (basic) min/week	.	.	.	-0.08	-0.26	<.001	.	.	.	.	.	.	0.034	0.117	0.025	.	-5.88	.	.	1.13
PT preparation time min/week	.	.	.	.	.	.	.	.	.	0.231	0.125	0.023	.	.	.	.	.	.	1.48	.
Speech therapy																				
ST auditory comprehension (advanced) min/week	.	.	.	.	.	.	.	.	.	0.278	0.206	<.001	.	.	.	.	.	.	1.50	.

Variable	Adm Cog <=6 Est	Std Est	p	Adm Cog 7-10 Est	Std Est	p	Adm Cog 11-15 Est	Std Est	p	Adm Cog 16-20 Est	Std Est	p	Adm Cog >=21 Est	Std Est	p	FIM points	FIM points	FIM points	FIM points	FIM points
N used	246			275			363			284			356							
R² pat, inj + POC act + LOE + meds	0.356			0.339			0.097			0.203			0.153							
ST auditory comprehension/expression (basic) min/week	.	.	.	.	.	.	.	.	.	-0.11	-0.15	0.009	.	.	.	.	.	.	-1.00	.
ST computer applications min/week	.	.	.	1.775	0.173	0.001	.	.	.	.	.	.	.	.	.	.	1.01	.	.	.
ST education min/week	.	.	.	0.229	0.154	0.003	.	.	.	.	.	.	.	.	.	.	2.84	.	.	.
ST expression (advanced) min/week	0.233	0.122	0.022	0.262	0.141	0.007	.	.	.	.	.	.	.	.	.	1.90	1.97	.	.	.
ST problem solving, math/money, memory/orientation (advanced) min/week	0.068	0.169	0.004	.	.	.	.	.	.	.	.	.	0.031	0.128	0.017	4.31	.	.	.	1.78
ST reading/writing (advanced) min/week	.	.	.	0.544	0.157	0.003	.	.	.	.	.	.	.	.	.	.	1.31	.	.	.
ST reading/writing (basic) min/week	.	.	.	.	.	.	.	.	.	-0.27	-0.15	0.015	.	.	.	.	.	.	-0.48	.
Psychology																				
PSY testing/assessment/behavioral min/week	.	.	.	.	.	.	.	.	.	0.03	0.129	0.023	0.036	0.178	<.001	.	.	.	1.51	1.49
Therapeutic recreation																				
TREC cognitive activity min/week	.	.	.	.	.	.	.	.	.	.	.	.	0.076	0.191	<.001	.	.	.	.	1.43
TREC sports min/week	.	.	.	-0.27	-0.21	<.001	.	.	.	.	.	.	.	.	.	.	-1.90	.	.	.
TREC community reintegration min/week	.	.	.	.	.	.	.	.	.	0.047	0.114	0.036	.	.	.	.	.	.	1.01	.
Medications																				
% of rehab stay on narcotic-analgesics	.	.	.	0.074	0.159	0.003	.	.	.	.	.	.	.	.	.	.	3.11	.	.	.
% of rehab stay on nonnarcotic-analgesics	.	.	.	.	.	.	.	.	.	-0.05	-0.12	0.041	.	.	.	.	.	.	-1.91	.
% of rehab stay on antipsychotics- second generation	.	.	.	.	.	.	.	.	.	-0.06	-0.12	0.029	.	.	.	.	.	.	-0.82	.
% of rehab stay on psychotherapeutics	.	.	.	.	.	.	.	.	.	.	.	.	-0.06	-0.1	0.042	.	.	.	.	-0.45

Legend:
- <-0.5 FIM points (red)
- -0.5 to 0 FIM points (orange)
- >0-0.5 FIM points (light green)
- >0.5 FIM points (dark green)
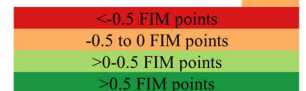
Figure 6.

Ordinary Least Squares Regression Models Predicting Rasch-Transformed 9-Month FIM Cognitive Score by Admission FIM Cognitive Score

Footnote. Red values indicate a negative association (coefficient), while green indicates a positive one. Dark green and red values indicate >+0.5 FIM points or <−0.5 FIM points, respectively. Light green and red values indicate +0.5 to 0 FIM points or −0.5 to 0 FIM points, respectively. Abbreviations: FIM, Functional Independence Measure; LOE, level of effort; CSI, Comprehensive Severity Index; PTA, post traumatic amnesia; OT, occupational therapy; PSY, psychology; PT, physical therapy; ST, speech therapy; TREC, therapeutic recreation.

Variable	Adm Cog <=6 (n=339)	Adm Cog 7-10 (n=374)	Adm Cog 11-15 (n=495)	Adm Cog 16-20 (n=408)	Adm Cog >=21 (n=504)
Rehab Length of Stay (LoS), R^2	0.3738	0.4828	0.5498	0.5482	0.5893
Discharge to home (dcH), c-Statistic	0.906	0.865	0.845	0.84	0.779
Discharge FIM Motor (dcM), R^2	0.7391	0.6988	0.626	0.6263	0.7644
Discharge FIM Cognitive (dcC), R^2	0.6394	0.5183	0.3948	0.3005	0.501
9-month FIM Motor (fuM), R^2	0.6454	0.5283	0.5097	0.3511	0.3479
9-month FIM Cognitive (fuC), R^2	0.3558	0.3385	0.0971	0.2029	0.1527
Demographic characteristics					
Age	**dcH dcM fuM fuC**	**dcH dcM fuM fuC**	LoS **dcH dcM** dcC fuM fuC	**dcH dcM fuM**	LoS **dcH dcM** dcC fuM
Male				fuM	dcC fuM
Race/Ethnicity black		fuM			LoS dcM fuM
Race/Ethnicity white	fuC			LoS fuM	dcC
Education: some high school, no diploma		fuC	fuM fuC	fuC	
Payer Medicaid	LoS fuM	LoS	fuM	**fuM**	
Pre-injury health information					
Substance use			dcM		dcH
Body Mass Index (BMI) <18.5				LoS	
Injury and rehabilitation stay characteristics					
Anxiety	dcC fuM	LoS fuC	LoS fuM fuC	dcH dcC	fuC
Depression	**LoS**	fuM		LoS	LoS fuM
% of rehab stay agitated			**dcM**	dcM	
Days from injury to rehab admission	LoS **dcM** dcC **fuM** fuC	**dcM** dcC **fuM** fuC	LoS dcM **fuM** fuC	**LoS fuM** fuC	**LoS fuM**
PTA cleared prior to rehab admission				**fuM**	
Maximum brain injury component of CSI score		**LoS**	LoS dcC	**LoS**	**LoS** dcH dcC
Maximum non-brain injury component of CSI score	dcM	**LoS** dcH	**LoS dcM fuM**	LoS	
Functional status characteristics					

Variable	Adm Cog <=6 (n=339)	Adm Cog 7-10 (n=374)	Adm Cog 11-15 (n=495)	Adm Cog 16-20 (n=408)	Adm Cog >=21 (n=504)
Rehab Length of Stay (LoS), R^2	0.3738	0.4828	0.5498	0.5482	0.5893
Discharge to home (dcH), c-Statistic	0.906	0.865	0.845	0.84	0.779
Discharge FIM Motor (dcM), R^2	0.7391	0.6988	0.626	0.6263	0.7644
Discharge FIM Cognitive (dcC), R^2	0.6394	0.5183	0.3948	0.3005	0.501
9-month FIM Motor (fuM), R^2	0.6454	0.5283	0.5097	0.3511	0.3479
9-month FIM Cognitive (fuC), R^2	0.3558	0.3385	0.0971	0.2029	0.1527
Admission FIM Motor Rasch-transformed	**LoS** dcM	**dcM** fuC	**LoS dcM dcC**	**LoS dcM** fuM	**LoS dcM**
Admission FIM Cog Rasch-transformed			**dcC**	LoS dcC	**dcC fuC**
Treatment factors					
Average OT, PT, ST level of effort	**dcH dcM dcC fuM fuC**	**dcH dcM dcC**	dcH **dcM dcC fuM**	**LoS** dcH **dcM** dcC fuM fuC	**dcC** fuC
Occupational therapy					
casting min/week	**dcM** fuM	**dcM**			
cognitive impairment min/week			LoS		**dcM** fuM
community IADLs min/week		dcM		dcM	
education min/week	**dcH** fuC	dcH	LoS dcH	LoS	LoS
evaluation min/week		LoS			
home IADLs min/week	**dcH dcM**		dcM		
physical impairments min/week	**dcM fuM**	**dcM** fuM	**dcM fuM**	dcM	**LoS**
wheelchair management min/week	fuM				
assessment min/week	dcH dcM	**LoS**			
bed/chair/WC transfer, feeding, dressing (basic) min/week		LoS dcM			dcH dcM **fuM**
personal care/transfers (advanced) min/week	dcH **dcM dcC**	LoS			
Physical therapy					
advanced locomotion min/week	**dcM**	**dcM**	**dcH**		

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9-month FIM Cognitive (fuC), R^2	0.3558	0.3385	0.0971	0.2029	0.1527
equip management, transitional movements (basic) min/week		**dcM** fuM **fuC**	LoS **dcM dcC**	dcH **dcM** fuM	**dcM** dcC fuC
formal assessment min/week	**LoS**	fuM	**LoS**	**LoS** dcH	**LoS**
pre-functional activity and therapeutic exercise min/week	**fuM**	dcC	dcM	dcH	dcC
pre-gait/standing min/week	**dcH**		dcH	dcC	
preparation time min/week		fuM	**LoS** dcM **fuM**	dcH fuM fuC	
resting min/week	**fuM**			LoS	
Speech therapy					
assessment min/week	LoS dcC	**LoS** dcM	**LoS** dcC	**LoS** dcC	**LoS** dcM
attention (both) min/week		fuM	**dcC**		
auditory comprehension (advanced) min/week		dcH	dcC **fuM**	dcH **fuC**	dcM
auditory comprehension/expression (basic) min/week	dcC	**dcC**	**dcC** fuM	**dcC** fuC	
community access/games min/week		**dcC**			**LoS** dcM dcC
computer applications min/week		fuM fuC			
education min/week	LoS **dcH**	LoS dcH fuC	LoS **dcH**	dcH	dcH dcC
expression (advanced) min/week	LoS **dcC** fuC	fuM fuC	**LoS**		**LoS**
motor speech (basic) min/week	dcM	dcH	LoS dcH **dcM dcC fuM**		
PMV/speaking valve/cork min/week	**fuM**				

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9-month FIM Cognitive (fuC), R^2	0.3558	0.3385	0.0971	0.2029	0.1527
problem solving, math/money, memory/orientation (advanced) min/week	**dcM dcC fuM** fuC	**dcM** dcC **fuM**		dcM	**fuM** fuC
reading/writing (advanced) min/week	dcC	**dcC** fuC			LoS
reading/writing (basic) min/week		**dcM fuM**		fuC	
swallowing min/week	LoS dcH				
Psychology					
cognitive remediation min/week		**LoS**			
total indirect min/week	dcM				dcC
general TBI education min/week			dcC		
information and history gathering min/week		LoS	LoS	**LoS**	LoS dcH dcM
testing/assessment/behavioral min/week		dcM dcC	fuM	fuC	**fuC**
Therapeutic recreation					
art min/week		LoS			LoS
cognitive activity min/week	dcC		dcC	fuM	dcM dcC **fuC**
sports min/week		**fuC**			dcH
community reintegration min/week			fuC		
Medications					
% of rehab stay on narcotic-analgesics		fuC		dcM	
% of rehab stay on nonnarcotic-analgesics		dcM fuM	dcM	dcC fuM fuC	
% of rehab stay on antianxiety agents		dcM	dcM		
% of rehab stay on anticonvulsants			LoS		
% of rehab stay on antidepressants- new SSRIs		dcH			fuM
% of rehab stay on antiparkinsonians		dcC	**LoS**	dcM	

Variable	Adm Cog <=6 (n=339)	Adm Cog 7-10 (n=374)	Adm Cog 11-15 (n=495)	Adm Cog 16-20 (n=408)	Adm Cog >=21 (n=504)
Rehab Length of Stay (LoS), R^2	0.3738	0.4828	0.5498	0.5482	0.5893
Discharge to home (dcH), c-Statistic	0.906	0.865	0.845	0.84	0.779
Discharge FIM Motor (dcM), R^2	0.7391	0.6988	0.626	0.6263	0.7644
Discharge FIM Cognitive (dcC), R^2	0.6394	0.5183	0.3948	0.3005	0.501
9-month FIM Motor (fuM), R^2	0.6454	0.5283	0.5097	0.3511	0.3479
9-month FIM Cognitive (fuC), R^2	0.3558	0.3385	0.0971	0.2029	0.1527
% of rehab stay on antipsychotics-second generation	**LoS** dcM dcC		dcC	fuC	
% of rehab stay on hypnotics			dcC	dcH	dcM
% of rehab stay on psychotherapeutics					fuC
% of rehab stay on stimulants		LoS dcC			

Figure 7.

Summary of Significant Covariates by Admission FIM Cognitive Score

Footnote. Red values indicate a negative association (coefficient), while green indicates a positive one. Bold values indicate p<0.001. Not bold values indicate p between 0.001 and 0.05.

Table 1

Patient, Treatment, and Outcome Variables by Admission FIM Cognitive Score

Variable	Overall (n=2130)	Adm Cog <=6 (n=339)	Adm Cog 7–10 (n=374)	Adm Cog 11–15 (n=495)	Adm Cog 16–20 (n=408)	Adm Cog >=21 (n=504)	P-Value
Demographic characteristics							
Age, mean (SD)	44.5 (21.3)	43.0 (21.9)	42.3 (20.0)	43.1 (20.9)	46.9 (21.6)	46.8 (21.8)	<.001
Male, (%)	72.5	71.7	76.5	75.8	71.3	67.7	0.018
Race/Ethnicity (%)							0.083
Black	15.1	15.3	13.9	16.8	15.4	13.9	
White non Hispanic	74.4	77.9	73.5	73.5	74.3	73.4	
White Hispanic	6.2	5.0	8.0	5.7	6.6	5.8	
Other and unknown	4.4	1.8	4.5	4.0	3.7	6.9	
Education: some high school no diploma (%)	22.9	20.1	25.9	25.1	26.7	17.5	0.002
Payer Medicaid (%)	15.5	20.9	18.2	16.4	17.2	7.7	<.001
Pre-injury health information							
Substance use (%)	51	45.4	57.5	51.7	52.9	47.6	0.009
Body Mass Index (BMI) <18.5 (%)	9.9	14.2	13.1	9.7	9.1	5.6	<.001
Injury and rehabilitation stay characteristics							
Anxiety (%)	40.8	32.4	46.5	45.3	41.4	37.5	<.001
Depression (%)	48.9	47.5	52.9	54.1	49.8	41.1	<.001
% of rehab stay agitated, mean (SD)	8.9 (19.4)	18.8 (25.2)	15.9 (25.1)	8.5 (17.8)	4.1 (12.9)	1.2 (7.2)	<.001
Days from injury to rehab admission, mean (SD)	29.3 (34.3)	36.5 (38.7)	34.2 (37.6)	27.5 (32.3)	26.0 (33.5)	24.9 (30.1)	<.001
PTA cleared prior to rehab admission (%)	40	1.2	8	25.7	62.5	86.5	<.001
Maximum brain injury component of CSI score, mean (SD)	48.4 (24.8)	77.2 (18.3)	66.8 (16.6)	50.8 (15.6)	36.1 (13.3)	22.0 (10.2)	<.001
Maximum non-brain injury component of CSI score, mean (SD)	24.8 (20.9)	30.6 (23.5)	30.7 (21.7)	25.8 (20.7)	22.7 (20.3)	16.8 (15.4)	<.001
Functional status characteristics							
Admission FIM Motor Rasch- transformed, mean (SD)	33.2 (19.3)	11.5 (14.5)	23.2 (16.4)	34.2 (14.8)	40.5 (12.5)	48.3 (15.2)	<.001
Admission FIM Cog Rasch-transformed, mean (SD)	37.2 (19.5)	2.5 (4.4)	25.7 (4.8)	38.4 (3.0)	47.5 (2.4)	59.6 (7.7)	<.001
Treatment factors							
Total minutes/week							

Variable	Overall (n=2130)	Adm Cog <=6 (n=339)	Adm Cog 7–10 (n=374)	Adm Cog 11–15 (n=495)	Adm Cog 16–20 (n=408)	Adm Cog >=21 (n=504)	P-Value
OT total min/week, mean (SD)	295.7	320.7 (91.1)	302.9 (90.9)	296.8 (95.6)	282.5 (109.4)	282.8 (120.9)	<.001
PT total min/week, mean (SD)	312 (111.9)	343.8 (94.9)	318.3 (100.1)	305.6 (102.8)	303.4 (116.7)	299.6 (130.8)	<.001
ST total min/week, mean (SD)	245.3	268.0 (108.0)	287.4 (103.6)	276.9 (114.2)	233.4 (113.2)	176.1 (126.5)	<.001
PSY total min/week, mean (SD)	64.9 (80.8)	41.7 (59.7)	60.2 (63.7)	82.8 (78.2)	72.9 (90.7)	60.1 (93.5)	<.001
TREC total min/week, mean (SD)	65.9 (73.1)	47.6 (52.2)	68.8 (65.9)	86.4 (82.8)	73.6 (76.4)	49.9 (71.3)	<.001
Average OT, PT, ST level of effort, mean (SD)	4.2 (0.9)	3.3 (0.8)	3.7 (0.7)	4.2 (0.6)	4.5 (0.6)	4.9 (0.7)	<.001
Occupational therapy							
casting min/week, mean (SD)	3 (10.8)	6.3 (16.5)	3.2 (9.0)	2.6 (9.2)	1.9 (9.1)	1.6 (9.0)	<.001
cognitive impairment min/week, mean (SD)	73.9 (62.5)	89.1 (67.6)	76.4 (57.6)	76.0 (60.3)	70.5 (59.6)	63.1 (64.9)	<.001
community IADLs min/week, mean (SD)	15.6 (28.5)	7.6 (14.4)	14.3 (23.9)	18.4 (29.4)	15.4 (25.8)	19.7 (37.6)	<.001
education min/week, mean (SD)	6.9 (11.7)	5.3 (9.4)	4.6 (7.2)	6.6 (11.2)	7.9 (11.8)	9.0 (15.4)	<.001
environmental adaption min/week, mean (SD)	0.5 (3)	0.3 (1.3)	0.6 (2.5)	0.7 (2.6)	0.5 (2.9)	0.4 (4.5)	0.311
evaluation min/week, mean (SD)	5.3 (12.4)	3.0 (6.9)	3.7 (8.7)	4.9 (10.9)	7.5 (16.0)	6.8 (15.0)	<.001
home IADLs min/week, mean (SD)	26.5 (26.4)	16.2 (18.1)	24.7 (27.1)	29.1 (25.6)	28.9 (26.7)	30.4 (29.0)	<.001
physical impairments min/week, mean (SD)	63.1 (57)	78.7 (57.9)	66.1 (52.3)	57.1 (47.4)	58.3 (53.6)	59.5 (67.8)	<.001
wheelchair management min/week, mean (SD)	1.7 (4.9)	2.2 (4.9)	1.6 (3.7)	1.5 (5.2)	1.5 (4.4)	1.6 (5.7)	0.22
assessment min/week, mean (SD)	27.3 (30.2)	14.6 (14.9)	18.3 (19.3)	27.7 (25.1)	27.6 (26.8)	41.8 (42.8)	<.001
bed/chair/WC transfer, feeding, dressing (basic) min/week, mean (SD)	51.2 (46.8)	73.8 (48.8)	65.5 (48.5)	50.3 (45.2)	43.0 (40.8)	32.8 (40.5)	<.001
personal care/transfers (advanced) min/week, mean (SD)	20.6 (21.2)	23.7 (22.5)	23.8 (20.1)	22.0 (19.5)	19.3 (21.8)	15.9 (21.5)	<.001
Physical therapy							
advanced locomotion min/week, mean (SD)	106.5 (86.1)	106.2 (84.2)	104.9 (79.7)	107.8 (77.2)	105.9 (91.4)	107.7 (95.8)	0.985
equip management, transitional movements (basic) min/week, mean (SD)	58.9 (59.9)	85.8 (56.1)	78.2 (65.9)	61.5 (60.6)	46.8 (52.2)	32.7 (48.1)	<.001
evaluation at patient home min/week, mean (SD)	0.2 (2.3)	0.1 (0.6)	0.0 (0.1)	0.2 (2.1)	0.2 (2.0)	0.3 (3.8)	0.433
formal assessment min/week, mean (SD)	26.4 (22.8)	14.3 (12.3)	18.3 (15.0)	26.0 (20.0)	28.7 (20.1)	39.3 (29.7)	<.001
pre-functional activity and therapeutic exercise min/week, mean (SD)	64.4 (48.1)	70.6 (52.6)	57.1 (39.8)	55.7 (42.0)	65.2 (45.4)	74.0 (55.7)	<.001
pre-gait/standing min/week, mean (SD)	28.2 (25.1)	34.0 (23.5)	32.1 (22.3)	28.9 (24.3)	25.4 (26.8)	23.0 (26.2)	<.001
preparation time min/week, mean (SD)	7.3 (9.5)	10.9 (11.9)	8.2 (10.2)	6.9 (8.7)	6.4 (8.4)	5.1 (8.1)	<.001
resting min/week, mean (SD)	20.2 (22.4)	21.9 (19.9)	19.6 (21.7)	18.6 (21.4)	24.9 (25.3)	17.4 (22.2)	<.001
Speech therapy							

Variable	Overall (n=2130)	Adm Cog <=6 (n=339)	Adm Cog 7–10 (n=374)	Adm Cog 11–15 (n=495)	Adm Cog 16–20 (n=408)	Adm Cog >=21 (n=504)	P-Value
assessment min/week, mean (SD)	40.3 (35.6)	35.1 (35.3)	32.9 (31.2)	40.9 (31.2)	42.2 (31.9)	47.5 (43.3)	<.001
attention (both) min/week, mean (SD)	6.5 (12.7)	6.8 (9.9)	7.6 (10.7)	8.0 (14.0)	7.1 (16.0)	3.6 (10.8)	<.001
auditory comprehension (advanced) min/week, mean (SD)	4.8 (9.1)	4.6 (7.5)	5.1 (8.0)	5.7 (9.3)	5.4 (11.7)	3.3 (8.2)	<.001
auditory comprehension/expression (basic) min/week, mean (SD)	20.2 (35.3)	52.4 (50.7)	32.4 (42.1)	13.3 (22.4)	9.3 (21.2)	4.5 (12.9)	<.001
augmentation devices min/week, mean (SD)	0.6 (5.9)	0.7 (5.4)	1.8 (11.2)	0.5 (5.4)	0.0 (0.3)	0.0 (0.1)	<.001
community access/games min/week, mean (SD)	34.6 (52.6)	23.0 (39.2)	40.0 (48.4)	49.0 (59.1)	34.8 (56.8)	23.9 (49.6)	<.001
computer applications min/week, mean (SD)	0.5 (2.6)	0.4 (2.3)	0.6 (2.4)	0.5 (2.2)	0.4 (2.5)	0.5 (3.2)	0.838
education min/week, mean (SD)	13 (14.4)	10.5 (12.2)	12.4 (12.2)	15.0 (14.4)	14.3 (14.9)	12.1 (16.7)	<.001
expression (advanced) min/week, mean (SD)	8.4 (14.2)	8.1 (12.2)	7.5 (11.0)	9.8 (14.1)	9.2 (15.7)	7.0 (15.9)	0.012
lip reading min/week, mean (SD)	0 (0.3)	0.1 (0.6)	0.0 (0.2)	0.0 (0.3)	0.0 (0.2)	0.0 (0.0)	<.001
motor speech (basic) min/week, mean (SD)	4.4 (13)	6.4 (14.6)	5.8 (13.8)	3.7 (11.2)	4.0 (13.6)	2.9 (11.9)	<.001
PMV/speaking valve/cork min/week, mean (SD)	0.6 (3.5)	1.6 (5.6)	1.0 (4.7)	0.4 (2.3)	0.2 (1.5)	0.2 (2.5)	<.001
problem solving, math/money, memory/orientation (advanced) min/week, mean (SD)	77.6 (60.6)	63.5 (50.3)	89.4 (58.6)	95.2 (60.6)	81.5 (62.2)	58.0 (59.7)	<.001
reading/writing (advanced) min/week, mean (SD)	3.4 (8.3)	1.8 (4.3)	2.4 (5.3)	3.6 (7.6)	4.4 (9.4)	4.4 (11.2)	<.001
reading/writing (basic) min/week, mean (SD)	2.5 (7.6)	3.7 (6.4)	3.9 (7.7)	2.8 (7.5)	1.8 (8.4)	1.0 (7.2)	<.001
swallowing min/week, mean (SD)	27.9 (41.5)	49.2 (45.7)	44.5 (46.2)	28.6 (40.4)	18.8 (37.1)	7.2 (23.3)	<.001
Psychology							
cognitive remediation min/week, mean (SD)	4.2 (25.3)	6.3 (30.3)	3.0 (20.0)	2.0 (12.0)	6.0 (33.7)	4.6 (27.0)	0.057
total indirect min/week, mean (SD)	1.2 (6.5)	1.4 (7.9)	1.5 (7.3)	1.0 (4.3)	1.3 (6.5)	0.9 (6.4)	0.56
general TBI education min/week, mean (SD)	7 (16.3)	3.0 (7.7)	6.9 (12.6)	10.4 (18.1)	8.0 (19.0)	5.4 (18.0)	<.001
information and history gathering min/week, mean (SD)	5.7 (10.2)	2.8 (8.3)	3.4 (5.6)	6.1 (9.9)	7.3 (10.3)	8.0 (13.1)	<.001
testing/assessment/behavioral min/week, mean (SD)	46.8 (61.1)	28.2 (37.3)	45.3 (49.5)	63.4 (64.4)	50.3 (66.6)	41.1 (69.4)	<.001
Therapeutic recreation							
art min/week, mean (SD)	3.5 (11.1)	3.1 (7.2)	4.2 (10.0)	4.8 (13.0)	2.9 (12.7)	2.4 (10.6)	0.005
cognitive activity min/week, mean (SD)	24.5 (37)	16.3 (24.3)	24.8 (34.7)	30.7 (40.5)	31.0 (42.7)	18.7 (35.5)	<.001
music min/week, mean (SD)	1 (4.6)	1.2 (5.0)	1.7 (5.8)	1.4 (6.0)	0.4 (2.8)	0.2 (1.9)	<.001
sports min/week, mean (SD)	6.5 (15.2)	5.6 (11.5)	7.1 (14.5)	8.4 (16.2)	7.5 (18.0)	4.1 (13.9)	<.001
community reintegration min/week, mean (SD)	14.1 (34.1)	7.9 (17.6)	13.0 (27.0)	21.5 (40.6)	14.4 (33.9)	11.5 (39.1)	<.001
Medications							

Variable	Overall (n=2130)	Adm Cog <=6 (n=339)	Adm Cog 7–10 (n=374)	Adm Cog 11–15 (n=495)	Adm Cog 16–20 (n=408)	Adm Cog >=21 (n=504)	P-Value
% of rehab stay on narcotic-analgesics, mean (SD)	47.2 (42)	39.8 (39.9)	42.0 (39.7)	45.5 (40.9)	52.3 (42.6)	53.8 (44.4)	<.001
% of rehab stay on nonnarcotic- analgesics, mean (SD)	38.4 (38.8)	37.6 (37.3)	33.7 (37.9)	33.6 (35.9)	39.7 (38.9)	46.4 (42.0)	<.001
% of rehab stay on antianxiety agents, mean (SD)	18.7 (35)	24.7 (38.5)	23.5 (36.5)	18.6 (35.1)	17.5 (34.9)	11.9 (29.5)	<.001
% of rehab stay on anticonvulsants, mean (SD)	38.2 (45.2)	38.7 (44.2)	40.1 (44.5)	38.6 (45.2)	40.4 (46.9)	34.2 (44.9)	0.232
% of rehab stay on antidepressants- new SSRIs, mean (SD)	9.8 (27)	10.0 (25.5)	12.0 (29.5)	9.7 (27.1)	10.3 (28.2)	7.4 (24.3)	0.161
% of rehab stay on antidepressants- other, mean (SD)	47.4 (44.2)	55.8 (43.6)	54.3 (42.8)	47.9 (44.7)	49.1 (44.0)	34.6 (42.6)	<.001
% of rehab stay on antiparkinsonians, mean (SD)	18.1 (34.9)	37.4 (42.1)	28.3 (40.1)	16.7 (34.3)	10.6 (27.1)	4.8 (20.3)	<.001
% of rehab stay on antipsychotics- second generation, mean (SD)	16 (32.9)	21.2 (34.3)	22.6 (37.4)	19.0 (36.4)	13.8 (30.8)	6.3 (22.3)	<.001
% of rehab stay on hypnotics, mean (SD)	18 (33.6)	20.4 (34.9)	23.1 (36.7)	19.0 (34.1)	14.1 (30.8)	14.6 (31.2)	<.001
% of rehab stay on psychotherapeutics, mean (SD)	12.5 (29.6)	14.1 (28.8)	12.4 (29.0)	15.2 (32.6)	14.6 (32.6)	7.0 (23.8)	<.001
% of rehab stay on stimulants, mean (SD)	18.5 (33.6)	38.5 (39.9)	30.7 (39.6)	16.0 (31.3)	9.9 (26.1)	4.9 (18.8)	<.001
Site, (%)							<.001
Site 1		0.3	1.9	2.4	6.4	20.4	
Site 2		18	35.6	35.4	20.3	11.7	
Site 3		1.8	2.9	3.2	3.9	4.4	
Site 4		7.4	12	13.1	18.6	11.3	
Site 5		12.4	4.5	6.7	6.4	7.9	
Site 6		13.9	5.9	5.1	7.4	9.9	
Site 7		2.9	6.4	7.5	4.4	4.6	
Site 8		6.8	4.5	5.5	4.2	7.3	
Site 9		23	12	8.3	13	7.3	
Site 10		13.6	14.2	12.9	15.4	15.1	
Outcomes							
Rehab length of stay excluding interruptions, mean (SD)	26.5 (19.9)	40.4 (27.6)	32.5 (18.4)	24.4 (15.4)	21.0 (15.5)	19.0 (15.1)	<.001
Discharge destination- home (%)	83.9	73.7	78.1	85.7	85	92.3	<.001
Discharge FIM Motor Rasch-transformed, mean (SD)	55.7 (15.9)	44.8 (17.5)	50.7 (13.7)	56.0 (12.6)	58.7 (13.2)	64.4 (15.4)	<.001
Discharge FIM Cog Rasch-transformed, mean (SD)	54.4 (15.1)	40.2 (18.0)	47.0 (10.6)	53.0 (9.4)	57.9 (8.5)	68.3 (11.1)	<.001
9-Month FIM Motor Rasch-transformed, mean (SD)	80.7 (20)	72.6 (25.0)	77.7 (20.8)	82.4 (19.1)	82.8 (16.8)	85.4 (16.4)	<.001

Variable	Overall (n=2130)	Adm Cog <=6 (n=339)	Adm Cog 7–10 (n=374)	Adm Cog 11–15 (n=495)	Adm Cog 16–20 (n=408)	Adm Cog >=21 (n=504)	P-Value
9-Month FIM Cog Rasch-transformed, mean (SD)	76.3 (17.9)	68.2 (20.6)	72.0 (18.7)	76.8 (16.6)	79.1 (16.2)	82.3 (14.8)	<.001

Table 2

Ordinary Least Squares or Logistic Regression Model Blocks for all Dependent Variables by Admission FIM Cognitive Score

Dependent Variable	Block	R²/c-Statistic Adm Cog <=6	R²/c-Statistic Adm Cog 7–10	R²/c-Statistic Adm Cog 11–15	R²/c-Statistic Adm Cog 16–20	R²/c-Statistic Adm Cog >=21
Rehab Length of Stay (LoS)	N used	338	366	481	382	400
	Patient, injury	0.1564	0.3121	0.4068	0.3931	0.4338
	Patient, injury + POC tot	0.204	0.3263	0.3985	0.3931	0.4643
	Patient, injury + meds	0.217	0.322	0.4322	0.3931	0.4487
	Patient, injury + LOE	0.1564	0.3121	0.4076	0.4056	0.4338
	Patient, injury + POC act	0.3382	0.4684	0.533	0.5302	0.589
	Patient, injury + POC act + LOE	0.3382	0.469	0.5331	0.5482	0.5893
	Patient, injury + POC act + LOE + meds	0.3738	0.4828	0.5498	0.5482	0.5893
	Patient, injury + POC act + LOE + meds + sites	0.4531	0.4828	0.5831	0.5837	0.5804
Discharge to home (dcH)	N used	339	373	493	407	502
	Patient, injury	0.734	0.793	0.778	0.748	0.712
	Patient, injury + POC tot	0.779	0.793	0.783	0.766	0.738
	Patient, injury + meds	0.734	0.793	0.778	0.789	0.712
	Patient, injury + LOE	0.753	0.816	0.788	0.764	0.713
	Patient, injury + POC act	0.896	0.858	0.841	0.792	0.778
	Patient, injury + POC act + LOE	0.906	0.844	0.845	0.802	0.779
	Patient, injury + POC act + LOE + meds	0.906	0.865	0.845	0.84	0.779
	Patient, injury + POC act + LOE + meds + sites	0.906	0.865	0.845	0.84	0.779
Discharge FIM Motor (dcM)	N used	339	373	493	407	502
	Patient, injury	0.3784	0.4789	0.4811	0.5363	0.7143
	Patient, injury + POC tot	0.4077	0.4916	0.4811	0.558	0.7222
	Patient, injury + meds	0.4143	0.4789	0.4811	0.5459	0.7163
	Patient, injury + LOE	0.5917	0.561	0.5344	0.5578	0.7151
	Patient, injury + POC act	0.6874	0.6475	0.5769	0.5908	0.7617
	Patient, injury + POC act + LOE	0.7417	0.6951	0.6249	0.6207	0.7619
	Patient, injury + POC act + LOE + meds	0.7391	0.6988	0.626	0.6263	0.7644
	Patient, injury + POC act + LOE + meds + sites	0.7391	0.7053	0.6325	0.6493	0.7759
Discharge FIM Cognitive (dcC)	N used	339	373	493	407	502

Dependent Variable	Block	R²/c-Statistic Adm Cog <=6	R²/c-Statistic Adm Cog 7–10	R²/c-Statistic Adm Cog 11–15	R²/c-Statistic Adm Cog 16–20	R²/c-Statistic Adm Cog >=21
	Patient, injury	0.2088	0.2102	0.1412	0.0958	0.4049
	Patient, injury + POC tot	0.2232	0.2189	0.1412	0.1066	0.4382
	Patient, injury + meds	0.229	0.2213	0.1563	0.1139	0.4115
	Patient, injury + LOE	0.5377	0.4193	0.2731	0.2217	0.4539
	Patient, injury + POC act	0.5294	0.3738	0.2419	0.164	0.4423
	Patient, injury + POC act + LOE	0.6452	0.5097	0.3847	0.2904	0.501
	Patient, injury + POC act + LOE + meds	0.6394	0.5183	0.3948	0.3005	0.501
	Patient, injury + POC act + LOE + meds + sites	0.6697	0.5586	0.4498	0.3469	0.5788
	N used	241	273	359	282	347
9-month FIM Motor (fuM)	Patient, injury	0.3792	0.3608	0.3892	0.2763	0.2528
	Patient, injury + POC tot	0.422	0.3608	0.3892	0.2763	0.2494
	Patient, injury + meds	0.4038	0.3772	0.3892	0.2903	0.2652
	Patient, injury + LOE	0.4675	0.3881	0.4136	0.3035	0.2298
	Patient, injury + POC act	0.6442	0.5036	0.5065	0.3147	0.3341
	Patient, injury + POC act + LOE	0.6454	0.5006	0.5097	0.3318	0.3324
	Patient, injury + POC act + LOE + meds	0.6454	0.5283	0.5097	0.3511	0.3479
	Patient, injury + POC act + LOE + meds + sites	0.6619	0.5283	0.5165	0.3511	0.38
	N used	246	275	363	284	356
9-month FIM Cognitive (fuC)	Patient, injury	0.1791	0.1841	0.076	0.0482	0.0891
	Patient, injury + POC tot	0.23	0.1982	0.076	0.0617	0.1173
	Patient, injury + meds	0.1791	0.1972	0.076	0.0941	0.0993
	Patient, injury + LOE	0.2698	0.1999	0.0858	0.0867	0.1121
	Patient, injury + POC act	0.3714	0.3079	0.1101	0.1614	0.1421
	Patient, injury + POC act + LOE	0.3558	0.3179	0.0971	0.1894	0.1425
	Patient, injury + POC act + LOE + meds	0.3558	0.3385	0.0971	0.2029	0.1527
	Patient, injury + POC act + LOE + meds + sites	0.3558	0.3352	0.0971	0.1887	0.1462