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Initiation of Physical, Occupational, and Speech Therapy in Children with Traumatic Brain Injury

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Abstract

Objectives—In hospitalized children with traumatic brain injury (TBI), 1) to determine factors associated with physical therapy (PT) or occupational therapy (OT) evaluation and speech or swallow therapy evaluation, 2) to describe when during the hospital stay the initial therapy evaluations typically occur, and 3) to quantify any between-hospital variation in therapy evaluation.

Design—Retrospective cohort study

Setting—Children's hospitals participating in the Pediatric Health Information System database, January, 2001 to June, 2011.

Participants—Children (age < 18 years) with TBI who were admitted to the ICU and survived to hospital discharge.

Interventions—Not Applicable

Main Outcome Measures—PT or OT evaluation and speech or swallow therapy evaluation. A propensity score was calculated to allow comparison of expected with observed rates of therapy evaluations by hospital.

Results—21,399 children met study criteria. The median hospital length of stay was 5 days (interquartile range 3-10 days). Overall, 41% (8,748/21,399) received either a PT or OT evaluation and 26% (5,490/21,399) received either a speech or swallow evaluation. Older children and those with higher energy injury mechanisms, more severe injuries, extremity fractures, more treatment with neuromuscular blocking agents or pentobarbital, and admission to a hospital with an American College of Surgeons Level I pediatric trauma designation were more likely to receive therapy evaluations. The median time until the first therapy evaluation was 5 days (PT or OT) and 7 days (speech or swallow). Expected hospital evaluation rates were 25-54% (PT or OT) and

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Conflicts of Interest: None

16-35% (speech or swallow), while observed hospital evaluation rates were 11-74% (PT or OT) and 4-55% (speech or swallow).

Conclusions—There is wide between-hospital variation in provision of rehabilitation therapies for children with TBI. Evidence-based criteria for initiation of routine therapy evaluations after TBI are needed.

Keywords

Pediatrics; Craniocerebral Trauma; Rehabilitation; Occupational Therapy; Speech Therapy

Pediatric traumatic brain injury (TBI) is estimated to cause approximately 2,300 deaths, 42,000 hospitalizations, and 404,000 Emergency Department visits annually among children 0-14 years old.^{1,2} TBI is also a major cause of acquired disability in children, with approximately 17,000 children permanently disabled each year.^{3,4}

Children who survive TBI may benefit from a comprehensive rehabilitation program.^{5,6} Evaluations by physical, occupational, speech, and swallow therapists are key components of the screening process to determine a patient's rehabilitation needs and opportunities for improvement. In addition, ongoing physical therapy (PT) or occupational therapy (OT) is required for admission to inpatient rehabilitation.⁷ Rehabilitation therapy initiation patterns have not been described in children with acute TBI.

The optimal time for initial therapy evaluations during the hospital course of a child with TBI is not known, but delay in initiation of a comprehensive rehabilitation program has been correlated with worse functional outcomes and decreased rehabilitation efficiency in children with severe TBI.⁸ The most recent published guidelines for the care of children with severe TBI do not address at what point after injury initiation of rehabilitation should occur.⁹

The objectives of this study were to use a large retrospective cohort of children with acute TBI from the Pediatric Health Information System (PHIS) database 1) to determine patient, injury, and hospital factors associated with therapy evaluation, 2) to describe when during the hospital stay the initial therapy evaluation typically occurs, and 3) to quantify any between-hospital variation in therapy evaluation.

Patients and Methods

Study Design

We conducted a retrospective cohort study of the Pediatric Health Information System (PHIS) database developed by the Children's Hospital Association (CHA) (Shawnee Mission, KS). We studied children who received care for TBI including intensive care unit (ICU) admission at a PHIS hospital and survived to discharge.

Setting

CHA is a business alliance of 44 children's hospitals, and PHIS contains administrative data including demographics, diagnoses, procedures, and charges. In addition, most PHIS

hospitals submit “Level II” data including billing information for pharmacy, imaging, laboratory, supply, nursing, and therapy services.¹⁰ Inpatient data on 36 PHIS hospitals have been published previously.¹⁰ All PHIS data are de-identified and checked for reliability and validity prior to their release, and data are accepted into the database only when classified errors occur in <2% of a hospital’s quarterly data.¹¹ The PHIS database contains records for more than 500,000 discharges per year.¹²

Selection of Participants

We obtained data from PHIS regarding patients meeting our inclusion criteria who also had supplemental billing (level II) data recorded (Figure 1). We identified children < 18 years of age discharged from a PHIS hospital between January, 2001 and June, 2011 with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) discharge diagnosis code for TBI and billing data for intensive care unit (ICU) admission (Figure 1). This set of ICD-9-CM diagnosis codes is used by the Centers for Disease Control (CDC) to track hospitalization and Emergency Department visits for TBI rates nationally.¹³

We calculated injury severity score (ISS, or specifically, ICD/ISS) and maximum abbreviated injury scale (AIS) body region scores from ICD-9-CM diagnosis codes using ICDMAP-90 software (Johns Hopkins University and Tri-Analytics, Inc., Baltimore, MD).¹⁴

We excluded patients who did not survive to discharge and would be unlikely to be candidates for therapy evaluation (Figure 1). In addition, we required patients to have at least “serious” head injury (maximum head body region AIS score = 3). We also excluded those with missing disposition information and duplicate or subsequent admissions by the same patient. We analyzed other subsets of the cohort in earlier work.^{15,16}

Covariates and Outcomes

We analyzed patient care across patient, hospital, and injury characteristics including American College of Surgeons (ACS) Pediatric Trauma designation (Tables 2 and 3).¹⁷ We categorized injury mechanism using the external cause-of-injury matrix created by the CDC (Table 3).¹⁸

The primary outcomes were PT or OT evaluation and speech or swallow evaluation, defined using Clinical Transaction Classification™ (CTC) codes (Table 1). CTC codes reflect hospital billing, and can be used to identify evaluations and services received by patients (for example, there are unique CTC codes for PT evaluation and PT services [Table 1]).^{10,11,15,19} We chose these primary outcomes to maximize the sensitivity of our analysis to situations we have observed in our clinical experience, particularly in the setting of resource limitations, in which, for example, physical or occupational therapists might provide overlapping services. The ICD-9-CM and CTC codes used for diagnoses and procedures are shown in Table 1.²⁰ We did not use the ICD-9-CM procedure code (93.0) for PT evaluation because there is no corresponding OT evaluation code and because its sensitivity was very poor: <0.5% of patients with CTC billing codes for PT evaluation also had that ICD-9-CM code (not shown).

The patient-level factors in the multivariate models were specified *a priori*: patient age at admission, mechanism of injury, head AIS, ISS, upper and lower extremity fractures, and number of days of treatment with a neuromuscular blocking agent (NMBA) or pentobarbital in the first week. We included age because we hypothesized that therapy evaluations would be less common in infants, mechanism of injury because it categorizes event energy (a fall from standing versus a motor vehicle crash, for example), head AIS because head injury severity is associated with degree of functional impairment²¹, ISS as a measure of global injury severity potentially requiring therapy evaluations, and extremity fractures, NMBA, and pentobarbital because they might contribute to immobility and/or weakness requiring therapy evaluation independent of brain injury.²² We did not include specific intracranial hemorrhage types (epidural hematoma without fracture, for example) because the ICD-9-CM coding does not reliably capture intracranial hemorrhages with fractures. We also did not include intracranial pressure monitoring or craniectomy because we suspected that they would be collinear with head injury severity and the medical therapies for intracranial hypertension.

Primary Data Analyses

We used the chi-square test for categorical variables and the Wilcoxon rank-sum test for continuous variables (length of stay, ICU days). We used linear regression with robust standard errors to test the slope of the relationships between the therapy evaluation rates and time. We used Kaplan-Meier analysis to estimate the time, in days after admission, to the first therapy evaluation.

To understand how much of the observed variation in therapy evaluation rate between hospitals could be attributed to patient factors (case mix at each hospital) versus hospital factors, we first standardized hospital-level rates of each therapy evaluation using a population-averaged logistic model with the pre-specified covariates described above. From this model, we estimated predicted probabilities of receiving a therapy evaluation for each patient (equivalent to a propensity score), and then used these probabilities to calculate expected hospital therapy evaluation rates. We then calculated standardized therapy evaluation rates for each hospital by comparing observed and expected rates in a manner similar to Weiss et al¹⁰ and our previous work.¹⁶

We then used a random-intercept logistic regression model including the same pre-specified covariates^{10,11,16} and the intraclass correlation coefficient to estimate variation in therapy evaluation rates between hospitals not related to patient factors.

To estimate the effect of candidate predictors on therapy evaluation, we used a multivariate logistic regression model. This model was populated with the pre-specified patient-level covariates described above and a categorical term for hospital ACS trauma level.

Statistical significance was defined as $p < 0.05$, and all analyses were performed using STATA™, versions 11 and 12 (StataCorp LP, College Station, TX). This study was reviewed and informed consent was not required by the School of Medicine Institutional Review Board.

Results

Characteristics of Study Subjects

We identified 31,916 patients with TBI and 21,399 remained in the dataset after exclusions (Figure 1). The median length of stay was 5 days (interquartile range [IQR] 3-10, range 1-372), and the median number of ICU days was 2 (IQR 1-4, range 1-171).

Overall, 23% of the patients were less than one year old (Table 2), and approximately one-quarter of the patients were injured in falls and another 25% in motor vehicle traffic events (Table 3). The “Other” insurance category (Table 2) includes patients coded by PHIS as “self-pay,” charity care, and “other payor.” Nearly three-quarters of the inflicted injury (72%) was in children < 1 year old. The most frequent (63%) head AIS score was 3, “serious,” and no patients had a head AIS score of 6, “unsurvivable” (Table 3). The median ISS score was 9 (IQR 9-16, range 4-75), and 45% had an ISS score > 15. All 4 patients with the maximum ISS score of 75 (“unsurvivable”) had the maximum Spine AIS score of 6.

Main Results/Bivariate Analyses

Overall, 41% (8,748/21,399) of patients received either a PT or an OT evaluation, 29% (6,119/21,399) received both evaluations, 9% (1,995/21,399) received only a PT evaluation, and 3% (634/21,399) received only an OT evaluation. Approximately one-third (6,901/21,399, 32%) of the patients received PT services, including 389 patients (6% of those receiving PT) who did not receive a PT evaluation. Only 19% (4,005/21,399) of patients received OT services, including 226 (6% of those receiving OT) who did not receive an OT evaluation. In the entire cohort, 35% (7,431/21,399) received either PT or OT services and 16% (3,475/21,399) received both PT and OT services.

Only 26% (5,490/21,399) of patients received either a speech therapy or a swallow evaluation: 6% received both, 14% received only a speech evaluation, and 5% received only a swallow evaluation. Of those who received a PT or OT evaluation, 56% (4,914/8,748) also received a speech or swallow evaluation. Among those who received a speech or swallow evaluation, 90% (4,914/5,490) also received a PT or OT evaluation. Overall, 18% of patients received speech or swallow therapy, including 70% (3,866/21,399) of those who received a speech or swallow evaluation.

Older children, children cared for at ACS level I hospitals, children with higher-energy injury mechanisms, those with extremity fractures, and more severely injured children (Tables 2a-2b and 3a-3b) were more likely to receive therapy evaluations in bivariate analyses. Intracranial hemorrhage and medical and surgical therapies for intracranial hypertension were also associated with PT or OT evaluation (Table 3a). Seventy-four children experienced cardiac arrest, of whom 59 (80%) received a PT or OT evaluation and 43 (58%) received a speech or swallow evaluation (not shown). Fifty-three percent of the children with a head AIS of 4 and 15% of the children with a head AIS of 5 received no therapy evaluations.

Monthly rates for PT or OT evaluation, adjusted for head injury severity, rose slowly over time (0.02% per month, 95% confidence interval [CI] 0.003 to 0.05% per month), with a

median of 169 patients per month (IQR 137-199). Monthly rates of speech or swallow evaluation, adjusted for head injury severity, also increased over time (0.04% per month, 95% CI 0.02 to 0.06% per month).

Kaplan-Meier Analyses

Among those who received a PT or OT evaluation, the median time from admission to evaluation was 5 days (IQR 3-8); for speech or swallow evaluation, the median time was 7 days (IQR 4-13). Kaplan-Meier estimates (censoring patients at the time of hospital discharge) of the proportion of patients still hospitalized who had received therapy evaluations by a given number of days since admission are shown in Table 4.

Hospitals and Between-hospital variation

Fewer than half of the hospitals had an ACS Pediatric Trauma designation (Table 2), and the median number of patients per hospital was 515 (range 46-1342, IQR 344-694). Observed rates of therapy evaluation were 11 to 74% (PT or OT) and 4 to 55% (speech or swallow), while expected rates based on propensity scores ranged from 25 to 54% (PT or OT) and 16 to 35% (speech or swallow) (Figures 2a and 2b). Two hospitals had very low rates of OT evaluation (<10% of patients) and near-median rates of PT evaluation (40-50%), but the remaining hospitals provided PT and OT evaluations at similar rates, i.e. low-use hospitals infrequently provided PT and OT evaluations, and high-use hospitals often provided both PT and OT evaluations (not shown).

Using a random-intercept logistic model adjusted for the same pre-specified covariates, we estimated from the intraclass correlation coefficient that 11.1% (PT or OT, 95% CI 7.3% to 16.4%) and 15.7% (speech or swallow, 95% CI 10.6% to 22.6%) of the total variance in therapy evaluation rates is between-hospital variance not explained by identified patient factors.

Predictors of PT or OT Evaluation

Using a multivariate logistic model, we found that older age, inflicted injury or motor vehicle traffic mechanism versus a fall, head AIS score of 5 versus 3, higher ISS, extremity fractures, and more days of chemical muscle relaxation were independently associated with therapy evaluations (Table 5). Additional days of pentobarbital therapy and care at a hospital with a Level I ACS pediatric trauma certification versus none were also independently associated with therapy evaluations, but the odds ratios were only modestly different than one.

Discussion

In this cohort of hospitalized children with TBI who were admitted to the ICU and survived to discharge, only 41% received either a PT or OT evaluation and only 26% received a speech or swallow evaluation during their hospitalization. We found that older children and those with inflicted injury or a motor vehicle traffic mechanism, greater head injury or overall injury severity, extremity fractures, more treatment with therapies associated with weakness and deconditioning, and admission to a hospital with a Level I ACS pediatric

trauma designation were more likely to receive therapy evaluations. There is significant between-hospital variation in obtaining therapy evaluations in children with TBI not accounted for by patient case mix. For those children who do receive therapy evaluations, the median time is 5 to 7 days after hospital admission.

We found significant between-hospital variation in therapy evaluation practice not explainable by patient factors or hospital ACS certification. This may be reasonable, given that there are no widely accepted standards for which children with TBI require therapy evaluations. However, more than half of the children in our study with a head AIS of 4 and 15% of those with a head AIS of 5 received no therapy evaluations. It seems likely that some of these children would have benefited from rehabilitation therapies. Slomine et al reported that, among children with TBI and head AIS = 4, 30% were still receiving PT services at 3 months and 19% at 12 months.²³ Many of those children were also still receiving OT and speech therapy at 3 months (19% and 20%, respectively) and 12 months (11% and 14%). PT, OT, and speech therapy use at 3 months (67%, 65%, and 66%, respectively) and 12 months (50%, 47%, and 47%) in that study were even higher in children with head AIS = 5. In general, wide variation in treatment methods not explained by patient-level factors is a marker for opportunities for care improvement.^{24,25} Rivara et al recently reported²⁶ substantial between-hospital and within-hospital variation in adherence to new quality-of-care indicators²⁷ for the acute rehabilitation of children with TBI. Unfortunately, these indicators were designed for the inpatient rehabilitation care of these children, and do not address rehabilitation therapies prior to transfer from the acute care hospital to inpatient rehabilitation.

The median times for the first therapy evaluations in our study were the 5th day of hospitalization (PT or OT) and the 7th day of hospitalization (speech or swallow therapy). In one recent report of children with TBI, delay in initiation of rehabilitation services including PT and OT was correlated with worse functional outcomes.⁸ Several recent trials and quality improvement projects in critically ill adults suggest a benefit to early initiation of PT and OT, prior to extubation in those on mechanical ventilators.²⁸⁻³⁰ Children with TBI may have unique risks that appropriately delay initiation of PT or OT such as worsening of intracranial hypertension with physical movement or stimulation. However, this occurs in a minority of patients, and peak intracranial hypertension risk generally passes prior to day 7. The appropriate time to initiate PT and/or OT in children with TBI is not yet completely understood, but there may be opportunities to improve outcome by initiating such therapies earlier in a hospital course.

We chose either a PT or an OT evaluation as one of our primary outcomes based on our clinical experience that in some hospitals there can be overlap in the roles of PT and OT providers. This assumption appears valid, as we found two hospitals that rarely performed OT evaluations but had near-median rates of PT evaluation. In general, however, the services were provided in tandem; most patients who received either a PT or OT evaluation also received the other type of evaluation.

Study Limitations

Our study has several limitations. Post-resuscitation Glasgow Coma Scale score, pupillary exam, and head computed tomography scan results, the most predictive measures of TBI severity, are not present in the PHIS database. We used AIS to measure head injury severity, and that scale has some limitations. For example, we were surprised to find that children with a maximum head AIS = 4 were less likely to receive therapy evaluations than children with maximum head AIS = 3. The PHIS database, unfortunately, does not include the specific “predot” injury codes that indicate a given patient’s maximum head AIS score.³¹ One possible explanation is that subdural hematomas were generally given a head AIS score of 4 prior to the 2005 AIS revision (ICD-9-CM has not been updated since the 2005 revision¹⁴), but subarachnoid hemorrhages were most often given a head AIS score of 3.³¹ Small or quickly evacuated subdural hematomas might be associated with quick return to baseline neurologic function and some providers might not feel that therapy evaluations are indicated. Subarachnoid hemorrhages can be associated with significant shear injury, and might be associated with worse outcomes and need for therapy evaluations. Overall, ICD-9-CM diagnosis codes for TBI do not allow ideal categorization of intracranial hemorrhages or ideal injury severity classification, and ICD-9-CM, while quite useful when analyzing administrative data, has limitations for use with TBI.

We restricted our analysis to those who survived to hospital discharge in order to identify a cohort that might benefit from therapy evaluations. In order to ensure that between-hospital variation in therapy evaluation practice was not a result of patient factors related to injury severity or location, we adjusted for age, mechanism of injury, head injury severity, overall injury severity, and both lower and upper extremity fractures.

Some trauma centers are certified by state organizations and not by the ACS, and as such some hospitals in the “No ACS certification” group are busy and prominent centers. Also, changes in hospital ACS trauma designation are not shown in the publicly available trauma center list.¹⁷

Conclusion

In this cohort of hospitalized children with TBI who survived to discharge, only 41% received a PT or OT evaluation and only 26% received a speech or swallow evaluation, with wide between-hospital variation. Older children and those with inflicted injury or a motor vehicle traffic mechanism, more severe head injuries, higher overall injury severity, extremity fractures, more days of NMBA and pentobarbital, and those who received care at a hospital with an ACS Level I pediatric trauma designation were more likely to receive therapy evaluations. Evidence-based criteria for initiation of routine therapy evaluations after TBI are needed. Earlier initiation of rehabilitation therapies deserves further study as a potential intervention to improve functional outcomes in children with TBI.

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Abbreviations

TBI	Traumatic brain injury
PT	Physical therapy
OT	Occupational therapy
PHIS	Pediatric Health Information System
CHA	Children's Hospital Association
ICU	Intensive Care Unit

ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
CDC	Centers for Disease Control
ISS	Injury Severity Score
AIS	Abbreviated Injury Scale
ACS	American College of Surgeons
CTC	Clinical Transaction Classification™
NMBA	Neuromuscular blocking agent
IQR	Interquartile range
CI	Confidence Interval

Figure 1.

Patient selection method for children < 18 years old with traumatic brain injury (TBI)

PHIS = pediatric Health Information Systems; ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; ICU = Intensive Care Unit; AIS = Maximum Abbreviated Injury Scale for Head body region, derived using ICDMAP-90

Figure 2.

a – Observed versus expected rates of PT or OT evaluation, by hospital

b – Observed versus expected rates of Speech or Swallow evaluation, by hospital

Table 1

CTC and ICD-9-CM codes for diagnoses and procedures

		ICD-9-CM codes	CTC codes
Diagnosis			
	Inflicted injury*	995.5, E960-968	
	Cardiac arrest	427.5, 997.1	
	Intracranial hemorrhage	800.2, 800.3, 800.7, 800.8, 801.2, 801.3, 801.7, 801.8, 803.2, 803.3, 803.7, 803.8, 804.2, 804.3, 804.7, 804.8, 852.0-852.5, 853.0-853.1	
	Skull fracture	800.x, 801.x, 803.x, 804.x	
	Upper extremity fracture	810.x-819.x	
	Lower extremity fracture	820.x-829.x	
	EDH, no fracture	852.4, 852.5	
	SAH, no fracture	852.0, 852.1	
	SDH, no fracture	852.2, 852.3	
Procedure			
	PT Evaluation		535011
	OT Evaluation		535012
	Speech Therapy Evaluation		535013
	Swallow Evaluation		535014
	PT Service	93.1, 93.2, 93.3	535110
	OT Service	93.83	535120
	Speech Therapy Service	93.72-93.75	535317
	Swallowing Therapy		535321
	ICP Monitor	01.10, 01.18, 02.2, 02.39	255551, 515005
	Craniotomy/Craniectomy	01.24, 01.25	

* These codes were used by Wood et al.³²

EDH = Epidural hematoma without skull fracture; SAH = Subarachnoid hemorrhage without skull fracture; SDH = Subdural hemorrhage without skull fracture; There are no equivalent ICD-9-CM diagnosis codes for EDH, SAH, or SDH with skull fracture (mixed hemorrhage codes are used); ICP = Intracranial pressure

Table 2

a – Patient and hospital characteristics of children with TBI, by PT or OT evaluation

	PT or OT evaluation, n(col%)	None, n(col%)	X ² p
	N = 8,748(41)	N = 12,651(59)	
Age			< 0.001
0 to 364 days	1,618(19)	3,396(27)	
1 to <5 years	1,850(21)	3,269(26)	
5 to <13 years	3,120(36)	4,113(33)	
13 to <18 years	2,160(25)	1,873(15)	
Gender			0.630
Male	5,625(64)	8,149(64)	
Missing	7(0)	6(0)	
Insurance status			< 0.001
Government	4,186(48)	5,734(45)	
Private	2,940(34)	4,518(36)	
Other*	1,526(17)	2,215(18)	
Missing	96(1)	184(1)	
Admission Date			0.627
10/2000-7/2003**	1,664(19)	2,373(19)	
8/2003-6/2011	7,084(81)	10,278(81)	
Length of stay, median(IQR)	10(6-21)	4(3-5)	< 0.001 ***
ICU days, median(IQR)	3(2-8)	1(1-2)	< 0.001 ***
ACS Trauma Level			< 0.001
I (16 hospitals)	3,978(45)	4,893(39)	
II (3 hospitals)	596(7)	889(7)	
None (22 hospitals)	4,174(48)	6,869(54)	
Patients per hospital			< 0.001
<300 (9 hospitals)	1,002(11)	585(5)	
300-600 (17 hospitals)	3,173(36)	4,441(35)	

	PT or OT evaluation, n(col%)	None, n(col%)	X ² p
>600 (15 hospitals)	N = 8,748(41)	N = 12,651(59)	
	4,990(57)	7,208(57)	
b – Patient and hospital characteristics of children with TBI, by Speech or Swallow evaluation			
	Speech or Swallow eval, n(col%)	None, n(col%)	X ² p
	N = 5,490(26)	N = 15,909(74)	
Age		0.005	
0 to 364 days	1,127(21)	3,887(24)	
1 to <5 years	1,214(22)	3,905(25)	
5 to <13 years	1,857(34)	5,376(34)	
13 to <18 years	1,292(24)	2,741(17)	
Gender			0.568
Male	53515(64)	10,259(64)	
Missing	2(0)	11(0)	
Insurance status			< 0.001
Government	2,704(49)	7,216(45)	
Private	1,808(33)	5,650(36)	
Other*	931(17)	2,810(18)	
Missing	47(1)	233(1)	
Admission Date			0.005
10/2000-7/2003**	966(18)	3,071(19)	
8/2003-6/2011	4,524(82)	12,838(81)	
Length of stay, median(IQR)	14(7-25)	4(3-6)	< 0.001***
ICU days, median(IQR)	4(2-10)	1(1-2)	< 0.001***
ACS Trauma Level			< 0.001
I (16 hospitals)	2,470(45)	6,401(40)	
II (3 hospitals)	347(6)	1,138(7)	
None (22 hospitals)	2,673(49)	8,370(53)	
Patients per hospital			< 0.001

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	PT or OT evaluation, n(col%)	None, n(col%)	X ² p
	N = 8,748(41)	N = 12,651(59)	
<300 (9 hospitals)	315(6)	1,272(8)	
300-600 (17 hospitals)	1,745(32)	5,869(37)	
>600 (15 hospitals)	3,430(62)	8,768(55)	

Column percentages may not add to 100% because of rounding

col% = column percentages;

* The "Other" insurance category includes patients coded by PHIS as "self-pay," charity care, and "other payor."

** Guidelines for the care of children with severe TBI were published in July, 2003³³ and updated in January, 2012.⁹

*** Wilcoxon rank-sum test

Table 3

a – Injury characteristics and treatments received, by PT or OT evaluation

		PT or OT evaluation, n(col%)	None, n(col%)	X ² p
		N = 8,748(41)	N = 12,651(59)	
	Mechanism			< 0.001
	Fall	1,109(13)	4,303(34)	
	Motor vehicle traffic	3,165(36)	2,084(16)	
	Inflicted Injury	1,548(18)	1,263(10)	
	Other/Missing	2,926(33)	5,001(40)	
	Head AIS			< 0.001
	3 (“Serious”)	4,999(57)	8,487(67)	
	4 (“Severe”)	3,154(36)	4,045(32)	
	5 (“Critical”)	595(7)	119(1)	
	ISS			< 0.001
	< 15	3,772(43)	7,897(62)	
	15	4,976(57)	4,754(38)	
	Upper extremity fracture			< 0.001
	Yes	1,237(14)	691(5)	
	Lower extremity fracture			< 0.001
	Yes	1,202(14)	448(4)	
	EDH, no fracture			< 0.001
	Yes	365(4)	858(7)	
	SAH, no fracture			< 0.001
	Yes	668(8)	761(6)	
	SDH, no fracture			< 0.001
	Yes	1,680(19)	1,908(15)	
	ICP Monitor			< 0.001
	Yes	2,440(28)	610(5)	
	Craniotomy/Craniectomy			< 0.001
	Yes	924(11)	1,103(9)	
b – Injury characteristics and treatments received, by Speech or Swallow evaluation				
		Speech or Swallow eval, n(col%)	None, n(col%)	X ² p
		N = 5,490(26)	N = 15,909(74)	
	Mechanism			< 0.001
	Fall	630(11)	4,782(30)	
	Motor vehicle traffic	1,970(36)	3,279(21)	
	Inflicted Injury	1,133(21)	1,678(11)	
	Other/Missing	1,757(32)	6,170(39)	
	Head AIS			< 0.001

		PT or OT evaluation, n(col%)	None, n(col%)	$\chi^2 p$
		N = 8,748(41)	N = 12,651(59)	
	3 ("Serious")	3,012(55)	10,474(66)	
	4 ("Severe")	2,010(37)	5,189(33)	
	5 ("Critical")	468(9)	246(2)	
ISS				< 0.001
	< 15	2,248(41)	9,421(59)	
	15	3,242(59)	6,488(41)	
	Upper Extremity fracture			< 0.001
	Yes	780(14)	1,148(7)	
	Lower Extremity fracture			< 0.001
	Yes	741(14)	909(6)	
	EDH, no fracture			< 0.001
	Yes	159(3)	1,064(7)	
	SAH, no fracture			< 0.001
	Yes	458(8)	971(6)	
	SDH, no fracture			< 0.001
	Yes	1,152(21)	2,436(15)	
	ICP Monitor			< 0.001
	Yes	1,894(35)	1,156(7)	
	Craniotomy/Craniectomy			0.239
	Yes	498(9)	1,529(10)	
	NMBA 2 days in first 7*			< 0.001
	Yes	1,495(27)	987(6)	
	Pentobarbital 2 days in first 7*			< 0.001
	Yes	487(9)	281(2)	

Column percentages may not add to 100 because of rounding

col% = column percentages; EDH = Epidural hematoma without skull fracture; SAH = Subarachnoid hemorrhage without skull fracture; SDH = Subdural hemorrhage without skull fracture; ICP = Intracranial Pressure;

* N = 20,970 patients had a length of stay of 2 days

Table 4

Kaplan-Meier estimates of proportion of patients who have received a PT or OT evaluation or a Speech or Swallow evaluation

		PT or OT Evaluation	Speech or Swallow Eval
		Estimated % (95% CI)	Estimated % (95% CI)
Days after Admission			
	1	5.8% (5.5-6.2)	2.5% (2.3-2.7)
	2	14.3% (13.8-14.8)	5.5% (5.2-5.9)
	3	23.4% (22.8-24.0)	9.3% (8.9-9.7)
	5	39.4% (38.6-40.3)	17.6% (16.9-18.2)
	7	51.3% (50.3-52.3)	25.5% (24.6-26.3)
	14	73.2% (72.1-74.3)	49.0% (47.7-50.2)

Table 5

Multivariate logistic models

		PT or OT evaluation	Speech or Swallow eval
		aOR (95% CI)	aOR (95% CI)
Age			
	0 to 364 days	1.00 (ref.)	1.00 (ref.)
	1 to <5 years	1.44 (1.30-1.60)	1.33 (1.19-1.49)
	5 to <13 years	1.80 (1.63-2.00)	1.39 (1.24-1.55)
	13 to <18 years	2.70 (2.43-3.02)	1.78 (1.58-2.01)
Mechanism			
	Fall	1.00 (ref.)	1.00 (ref.)
	Motor vehicle traffic	3.09 (2.81-3.41)	2.67 (2.39-2.98)
	Inflicted Injury	4.20 (3.73-4.73)	4.32 (3.80-4.92)
	Other/Missing	1.61 (1.48-1.76)	1.65 (1.48-1.83)
Head AIS			
	3	1.00 (ref.)	1.00 (ref.)
	4	0.68 (0.60-0.77)	0.79 (0.70-0.89)
	5	1.98 (1.56-2.52)	2.02 (1.66-2.46)
ISS			
	< 15	1.00 (ref.)	1.00 (ref.)
	15	1.95 (1.73-2.20)	1.63 (1.45-1.84)
Upper Extremity fracture			
	No	1.00 (ref.)	1.00 (ref.)
	Yes	1.52 (1.36-1.70)	1.30 (1.16-1.45)
Lower Extremity fracture			
	No	1.00 (ref.)	1.00 (ref.)
	Yes	2.04 (1.80-2.32)	1.29 (1.14-1.45)
NMBA			
	Each additional day *	2.05 (1.97-2.14)	1.75 (1.69-1.82)
Pentobarbital			
	Each additional day *	1.12 (1.06-1.17)	1.14 (1.09-1.18)
Hospital ACS Trauma level			
	None	1.00 (ref.)	1.00 (ref.)
	I	1.28 (1.20-1.36)	1.13 (1.05-1.21)
	II	1.13 (0.99-1.27)	0.97 (0.84-1.11)

aOR = adjusted Odds Ratio;

*
in the first week