I, Lynn Babcock M.D., hereby submit this original work as part of the requirements for the degree of Master of Science in Clinical and Translational Research.

It is entitled:
Predicting Post-Concussion Syndrome After Mild Traumatic Brain Injury in Children

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This work and its defense approved by:

Committee chair: Erin Nicole Haynes, DrPH
Committee member: Shari Wade, PhD
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Predicting Post-Concussion Syndrome After Mild Traumatic Brain Injury in Children

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by

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Committee Chair: Erin N. Haynes, DrPH
Abstract:

*Background:* A cluster of cognitive, physical, emotional / behavioral and sleep problems referred to as post-concussion syndrome (PCS) occurs following mild traumatic brain injury (mild TBI) in a subset of children. Limited evidence suggests that patient and injury characteristics contribute to the development of PCS.

*Objective:* To determine the acute predictors associated with the development of PCS in children.

*Methods:* Retrospective analysis of a prospective observational study of children ages 5 to 18 years presenting to the Emergency Department (ED) with mild TBI. All patients had data related to the injury recorded during the initial ED visit. Telephone follow-up administration of the Rivermead Postconcussion Questionnaire was conducted at three months post injury. In a convenience sample, serum was analyzed for the biomarker S100B. Univariable and multivariable logistic regressions were performed.

*Results:* 29% of children presenting to the ED with mild TBI developed had PCS. The most frequent PCS symptom was headache. Predictors of the development of PCS were age, headache on presentation in the ED and admission to the hospital, while controlling for other covariates. S100B levels alone did not predict development of PCS. Children who developed PCS missed, on average, 7.4 (SD 4.9) days of school.

*Conclusions:* Children, who were older, had headache on ED presentation and required hospital admission at ED encounter, were at high risk of PCS following TBI. Interventions to identify and begin early treatment for this population may be of benefit to improve outcomes and reduce burden of disease.
Acknowledgements:

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**Background:**

There are over 473,000 annual emergency department (ED) visits for children with traumatic brain injuries (TBI) in the United States and approximately 75% of these are defined as “mild” (mild TBI).\(^1\)\(^2\) Mild TBI involves a complex pathophysiologic process that can occur following direct or indirect traumatic forces to the head. Following minor blows to the head, some children develop a cluster of cognitive, physical, emotional / behavioral and sleep problems commonly referred to as post-concussion syndrome (PCS) that can persist for days to years.\(^3\)\(^-\)\(^7\) The National Institutes of Health has deemed mild TBI as a societal burden due to the sheer volume of children who suffer this condition, as well as the risk of enduring neurocognitive sequelae.

There remains no reliable tool at the time of injury that can predict those who develop PCS. The current ED evaluation for children presenting with a blow to the head tends to focus those signs and symptoms that may predict an abnormal computed tomography (CT) scan, yet the cranial CT is normal in the vast majority of patients with mild TBI.\(^8\) The ability of these acute signs and symptoms of TBI to predict post-concussion syndrome has not been clearly established. Identify the population who are at risk of poor functional outcomes would aid in referring those who could benefit from therapy. In adults, being of the female gender, intent to sue at 3 months follow up, presence of skull fracture, dizziness in the ED and headache in the ED are predictors of PCS following mild TBI.\(^9\)\(^10\) In several reports involving the same cohort of 186 children with mild TBI, loss of consciousness (LOC), nausea, dizziness, disorientation and other mental status changes, presence of 4 or more acute mild TBI symptoms at the time of
ED presentation, motor-vehicle-related trauma, injuries to other body regions, neuroimaging abnormalities, and hospitalization have all been associated with persistence and severity of PCS. Early identification and administration of injury-specific information, such as cognitive rest and headache management, as well as recommending post-injury coping strategies in both adults and children has been shown to improve post-mild TBI functioning. Thus, early identification of those at risk could lead to different management approaches.

In addition to traditional signs and symptoms, a biomarker of mild TBI would be useful if it could predict the extent of injury and development of PCS. One of the most studied serum biomarkers is S100B, a calcium-channel binding protein that is highly expressed in the astroglial cells of brain tissue. In adults, serum S100B has been found to be elevated following mild to severe TBI, correlated with indices of severity, and predictive of abnormalities on CT scan. However, there are conflicting reports as to its ability to predict PCS in adults. In several small studies involving children, S100B has not proven to be as sensitive of a biomarker of TBI as in adults. Although there are a few reports that suggest that it can predict outcomes following more severe grades of TBI in children, there is little evidence as to its usefulness to predict outcome following mild TBI.

The objective of this study was to determine the incidence of PCS and to identify predictors of PCS following mild TBI in a cohort of children who presented initially to the ED. We hypothesized that there would be a set of risk factors for the development of PCS easily captured in the ED that would help to risk-stratify the need for ongoing follow-up in this population. In addition, we explored the ability of the serum marker
S100B to predict PCS in children following mild TBI in a convenience sample within the cohort.

**Patients and Methods**

**Subjects and Settings**

This is a secondary analysis of a previously established larger prospective cohort of consecutive TBI patients of all ages who consented to participate in a National Institutes of Health funded TBI registry study. The study was designed to describe the epidemiology and outcomes of ED patients with mild TBI at three months. The original cohort was recruited at the University of Rochester Medical Center EDs (Pediatric and Adult) between January 7, 2003 and September 6, 2004. The Pediatric ED, which is located adjacent to the General ED, treats over 28 000 visits per year, serves a population of 1 million people and is the regional pediatric tertiary care and trauma center.

Patients were eligible for inclusion in the study if they met the case definition of mild TBI developed by the Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine. This definition consists of a blow to the head or acceleration/deceleration movement of the head resulting in one or more of the following: loss of consciousness <30 minutes, amnesia <24 hours or any alteration in mental state at the time of the injury and a Glasgow Coma Scale (GCS) of ≥13 measured 30 minutes or more after injury. There was no exclusion for those with suspected or established drug/alcohol use.
**Study Design**

In the ED, subjects were identified by trained research assistants who typically staffed the ED seven days per week from 8 am to midnight. All suspected cases of mild TBI were confirmed by the board eligible/certified pediatricians or emergency physicians attending to the patient. Research assistants collected clinically relevant information directly from the subjects and/or parent/guardian before the patient left the ED. These data included demographic factors (race, ethnicity, age, insurance information, and gender), history of prior TBI, mechanism of injury, clinical signs and symptoms of TBI (loss of consciousness, amnesia, alteration of mental status, nausea/vomiting, and headache), physical exam factors (Glasgow Coma Scale), results of neuroimaging (if performed), ED medication administration, receipt of injury specific discharge instructions, referrals and disposition. For questions such as history of prior TBI, loss of consciousness, amnesia, nausea/vomiting, alteration of mental status or headache, subjects/guardians were given 3 possible responses: yes, no or unsure. In the clinical setting, it is difficult to interpret the response of “unsure,” and a response of “unsure” does not assuage the clinician’s concern about the presence of that symptom, so “unsure” responses were grouped with the yes responses for this analysis. Severe mechanism of injury was defined as any of the following: motor vehicle collision, a pedestrian struck by a motor vehicle, a bicyclist without a helmet or a fall ≥ 3 feet. Other diagnoses at the time of the injury visit were determined by a post-hoc review of subjects billing charts for non-TBI ICD-9 codes. An abnormal cranial CT was defined by the presence of any intracranial injury, including subdural hematomas, epidural hematomas and cerebral contusions, as well as the presence of skull fractures.
In year two, from January to September 2004, a convenience sample of subjects was approached to have their blood drawn for serum marker analysis. Because S-100B levels have been shown to peak and then normalize within 6 hours of TBI, subjects presenting more than 6 hours after injury were not eligible for this part of the study. To minimize confounds, patients with preexisting medical or psychiatric conditions known to be associated with an elevated S-100B level in the absence of TBI were excluded; these included Down’s syndrome, schizophrenia, and recent history of excessive strenuous exercise. Among those consenting, four milliliters of venous blood was drawn. The sample was then centrifuged at 3000 rpm for 10 minutes at room temperature. The resulting serum was immediately placed in a freezer at -20°C. After additional funding was secured in the fall of 2007, samples were analyzed for S100B with an enzyme immunoassay test kit (Nanogen, San Diego, CA) using a Microplate Reader Model 550 (Biorad, Hercules, CA). This is a two site, sandwich type immunoassay using monoclonal antibodies. The concentration of S-100B protein in the samples was determined by measuring the absorbance of the samples at 450nm. A set of standards was used to produce a standard curve of absorbance versus protein concentration from which relative concentrations in the unknown samples were established.

Three months after the initial ED visit, subjects or their parents/guardians were interviewed by telephone. The respondent varied depending on availability and ability to complete the interview. From the interviews, the following information was collected: number of days of school or work missed due to the TBI, post-concussive symptom score using the Rivermead Postconcussive Questionnaire (RPQ) and if they intended or
were in the process of a lawsuit surrounding the injury. The telephone interviewers were blinded to the details of the initial ED presentation and to the result of the serum marker analysis. The RPQ is a 16 question survey which has been previously validated in mild TBI patients. Each question asks the subjects to rate the severity of 16 different symptoms commonly found after mild TBI. The subjects or their parent/guardian was asked to rate how severe each of the 16 symptoms has been since the injury on a scale from 0 to 4: absent (0), same (1), mild (2), moderate (3), or severe (4). In each case, the subject was asked to rate the severity of the symptom to that prior to injury. According to the International Classification of Diseases, 10th revision code, PCS is defined by the presence of at least 3 symptoms such as headache, dizziness, fatigue, irritability, sleep disturbance, concentration problems, memory problems and problems tolerating stress/emotion within four weeks of injury. Hence PCS was defined as the presence of 3 or more symptoms on the RPQ that were worse (scale of 2 or more) than pre-injury in this study.

This study cohort was limited to those that completed follow-up and to verbal children (ages ≥ 5 to 18 years). The Research Subject Review Board at the University of Rochester approved the parent study and all secondary analyses. The Institutional Review Board at Cincinnati Children’s Hospital Medical Center deemed that the secondary analysis was not human subject research.

**Data Analysis**

Data were summarized using frequencies and percentages for categorical data and means and standard deviations for continuous variables. The dependent variable
was the presence or absence of PCS. Comparisons of variables collected in the ED between those that completed the follow-up to those that were lost to follow-up were made using the chi square test. An a priori significance level of 0.05 was used for all statistic tests. The relationship between the independent variables and the dependent variable were assessed using chi square tests and univariable logistic regression. Receiver operating characteristics (ROC) curve analysis for S100B was used to determine the ability of S100B in the ED on presentation to predict PCS.

A multivariable logistic model using step-wise regression was developed to determine significant acute clinical predictors for PCS. Multicollinearity amongst the independent variables was examined via bivariate correlations. The ability of the model to predict the outcome was measured by the Hosmer-Lemeshow goodness of fit test and the C-statistic (area under the curve). Data analysis was performed in SAS\textsuperscript{R} 9.22 (Cary, NC).

**Results**

There were 481 children who were aged 5 years and older enrolled in the ED during the initial cohort study. 406 (84.4\%) children completed follow-up. Comparisons of completers versus children who were lost to follow-up revealed that completers were more likely to be of white race (84.5 vs. 54.7\%, p<0.0001), non-Hispanic (94.1 vs. 82.3\%, p=0.001) and have private insurance (72.9\% vs. 44.0\%, p <0.0001). Completers also presented less frequently with loss of consciousness (53.0 vs. 69.3\% yes/unsure, p=0.009), yet were more likely to have received specific mild TBI discharge instructions (63.1 vs. 50.0\%, p=0.04).
Of the 406 follow-up interviews, 145 (35.7%) were completed by the children themselves, whereas 261 (64.3%) were completed by their parents/guardian. Despite considerable overlap in ages, self-completers tended to be older than children whose parent/guardian completed the interview (mean age 14.8, SD 2.6 vs. 12.3, SD 3.7 years, p<0.0001). For all those that completed, the median age was 14.5 years (range 0-18) and the mean score on the RPQ was 6.83, SD 9.78 with a median of 2.0 (range 0-56). 34.2% of the patients had a score of zero. Other demographic data for the entire cohort is presented in Table 1. Headache was the most common symptom following the injury on the RPQ, reported by 30.5%. The frequency and severity of each PCS symptom for the entire cohort are shown in Figure 2.

A total of 119 (29.3%) of the children had PCS as defined by the presence of 3 or more symptoms on the RPQ conducted at 3 months that were worse than pre-injury by self or parent/guardian report. Using this definition, the mean RPQ scores were significantly different between those that had PCS and those that did not (2.2, SD 3.6 vs. 18.0, SD 10.9; p <0.0001). The mean or frequency of each independent variable in the children who had PCS and those who did not, as well as the ability of each independent variable to predict PCS in children following mild TBI are presented in Table 2. In summary, children who developed PCS were older and more likely to present with headache following their TBI. In addition, children who developed PCS were more likely to have had a cranial CT performed in the ED, to have received analgesics in the ED and to be admitted to the hospital for further management. All children experienced considerable school absenteeism following the TBI and this was also associated with the development of PCS. Children who developed PCS missed on
average 7.4 days, SD 4.9. Lastly, 19.3% of children who developed PCS indicated that they were in the process or have the intent to file a lawsuit pertaining to the injury as compared to 5.6% of those who did not develop PCS.

Within this study cohort, there were 76 children who had S100B levels measured. In those who had levels drawn, there was no significant difference in the mean S100B level for children who developed PCS and children who did not experience PCS (0.022 µg/L, SD 0.031 vs. 0.092 µg/L, SD 0.375; p=0.2). Similarly, ROC analyses failed to show that S100B alone was significant (0.46, OR 0.13, 95% CI 0, 28.6) for predicting children who develop PCS following mild TBI.

In the multivariable model, potential acute predictors of PCS were included based on clinical relevance, availability in the ED, prior published correlation and their relationship with the dependent variable in this study. Ethnicity was omitted from consideration since it was missing > 5% of the time. Since other diagnoses were not prospectively collected and their severity was not graded, they were also excluded from the model. The mode of arrival, although a potential indicator of severity, is often a measure of accessibility to the ED, thereby limiting the generalizability of this variable to other populations. As a consequence, it was also excluded from the model. Since S100B was only collected in a small sample of children, it was also not included. Multicollinearity (correlation coefficient >0.8) was not identified amongst any of the acute clinical variables; however, a significant association was found between insurance and race. Given their potential importance, both of these variables were included in the multivariable model. The final model included age, gender, race, insurance, prior TBI, severe MOI, GCS<15, LOC, headache, amnesia, nausea/vomiting, other MS changes,
A total of 402 (99%) subjects had complete data for inclusion in the model. After controlling for the presence of other variables, significant acute predictors for PCS were age (estimate 0.09, OR 1.10, 95% CI 1.02, 1.17), presence of headache (estimate 0.94, OR 2.56, 95% CI 1.47, 4.44), and admission to the hospital (estimate 1.00, OR 2.73, 95% CI 1.39, 5.35). The overall model had demonstrated moderate fit as assessed by Hosmer-Lemeshow ($\chi^2$ 8.2, DF 8, $p = 0.41$) and the c statistic (c= 0.68, 95% CI 0.64, 0.75).

**Discussion**

Over 29% of children in this study who presented to the ED at a tertiary trauma center following a mild TBI developed PCS and those children missed an average of over a week of school as a result of their injury and the associated sequelae. Given the nationally reported incidence of TBI along with this high incidence of PCS and the resultant school absenteeism, it is clear that PCS is a significant public health burden for children. We developed a robust model that identified key variables at the initial ED visit that predict the development of PCS including age, presence of headache in the ED and admission to the hospital after ED evaluation. Awareness of these factors can help the clinician recognize children at elevated risk for persistent PCS and deliver more appropriate individualized post-injury care to these children. This tailored approach and deployment of resources potentially reduce the burden of this disease.7

Direct comparison of our incidence data to other studies is limited due to differences in inclusion criteria and outcome definitions. In a large study of 670 children...
with mild TBI, Barlow et al\textsuperscript{37} reported 58.5\% of children who presented to the ED were still symptomatic at one month, whereas only 11\% were symptomatic at three months. Similarly, other investigators have shown a high incidence of symptoms immediately following injury which improves over time but still leaving 11 to 17\% with impairment at 3 months.\textsuperscript{37,38} Our finding of 29\% incidence of post-concussion syndrome following ED presentation for mild TBI was just a one-time report assessing the presence of symptoms at any time following the injury. Despite this limitation, our study supports the notion that there is a significant proportion of children who sustain mild TBI that go on to develop sequelae. However, the longer term effects of mild TBI on children are still unclear. In a recent systematic review\textsuperscript{39} sponsored by the WHO, it was reported that the majority of studies did not demonstrate long-term cognitive or behavioral deficits attributable to mild TBI, yet there are some reports of increased hyperactivity\textsuperscript{40}, visual defects\textsuperscript{41,42} and reading impairments\textsuperscript{41} following injury.

Early identification of patients who are likely to develop sequelae would assist in post-injury discharge planning in the ED. Several smaller studies of children have suggested that there may be a set of variables that predicts PCS and its trajectory. In a case-control study involving 186 children with mild TBI, Yeates and al\textsuperscript{11} found that the presence of 4 or more acute clinical symptoms of TBI were associated with persistence of PCS (≥1 month). In another study of 107 high school athletes, on field dizziness was the only symptom that predicted risk of protracted recovery. Aside from historical and self-reported symptoms, the use of an objective computerized neurocognitive post-concussion assessment test performed a few days after the injury was also found to be useful in identifying high school athletes at risk of protracted recovery.\textsuperscript{43} These studies
were limited by small sample sizes involving select populations, not allowing for more detailed investigation of acute predictors of PCS for all children. Within our large epidemiologic data set, we were able to explore the relationship of comparable variables collected at the time of injury to a single measurement of PCS performed at 3 months. The presence of headache in the ED was significantly related to the development of PCS. Interestingly, headache was also the symptom that was rated as most severe at 3 months. Discharge instructions need to give specific guidance about the management of headache, as well as the potential need for active interventions in those with persistent pain such as the use of analgesics, activity restrictions, biofeedback, and other coping strategies. As previously mentioned, simply giving discharge instructions detailing the symptoms and course of PCS has been shown to decrease the incidence and severity of symptoms.7 Detailed review of these discharge instructions with the child and their family is necessary. Other evidence-based interventions for children with mild TBI are lacking at this time.

There are several studies that have looked at PCS symptoms and the course of PCS symptoms in hospitalized patients.44,45 Given that hospital admission is a predictor of severity of symptoms following mild TBI, these results should be reviewed with some caution as this patient population is more likely to have severe symptoms initially. Only 10.4% of our cohort was admitted, yet this was associated with PCS. Talyor et al12 also found that hospital admission was associated with increased levels of PCS in a cohort of 186 children. Multiple factors go into the decision for admission and are related not only to severity of symptoms, but time of day, parental preference and physician practice. These contributing factors are difficult to tease out in most studies unless the
reason is directly queried. In addition, concomitant injuries or illnesses may affect this
decision. In our study, these were not prospectively collected. Interestingly, lower initial
GCS, a more objective measure of severity, was not significantly related to development
of PCS, yet only 4.9% of children had a GCS of less than 15. Increased personal and
family stress surrounding the injury and admission to the hospital may contribute to
severity of PCS symptoms.46,47 Future design of similar studies should clarify the
reason for admission, delineate associated injuries and illnesses, and include measures
of personal and family functioning.

Some reports suggest that damage to the developing brain may be more harmful
than equivalent damage to a mature brain.48-50 High school athletes have been found to
have a higher incidence of persistent symptoms over 10 days and required longer
recovery periods than adult athletes after mild TBI.51 Given that the median age in our
cohort was 14.5 years, over 50% of the children were high school age / adolescents.
Age may contribute to increased force precipitating the injury; however, there was no
significant correlation with age and severity of mechanism of injury. Older children may
be able to better articulate their symptoms than younger children and tend to rate their
symptoms as more severe than parents; thus, their responses on surveys may be more
accurate than those completed by younger children or parents. Clinicians should
recognize that adolescents are particularly affected by PCS symptoms and provide
appropriate guidance and follow-up. Although other factors thought to contribute to
PCS, such as prior TBI52, female gender9 and amnesia53, were not found to be
associated with development of PCS in our study, it cannot be inferred that they are
unrelated to the development of PCS. It may imply that these factors do not contribute to the development of the syndrome after controlling for several other factors.

In this small convenience sample of children with mild traumatic brain injury, S100B did not predict PCS. This adds to the body of conflicting literature about the usefulness of this marker for predicting injury or outcomes in children with mild TBI.\textsuperscript{17-19} In children, studies have found that there is an association between higher levels and poorer outcomes for children with moderate and severe TBI.\textsuperscript{54-56} Although S100B has been shown to correlate with abnormal CT findings for adults with mild TBI\textsuperscript{24}, its ability to predict outcomes is similarly debatable\textsuperscript{19,27}.

As was found in adults who sustained a TBI\textsuperscript{57}, the intent to sue was strongly associated with the development of PCS. Controversy exists around the validity of the subjective symptoms within the definition of PCS and the notion of malingering for secondary gain. In a case control study in adults conducted by Bazarian et al\textsuperscript{57}, intent to sue was the strongest predictor of developing PCS after controlling for demographic data and multiple clinical variables. Female gender (OR=7.8; 95\%CI 1.98, 41.67) and presence of amnesia (OR=0.055, 95\%CI 0.002-0.47) were the only other variables that were predictive of developing PCS at 1 month. For children with mild TBI, this association has not been reported. Because intent to sue is not known at ED presentation, it may not be useful to the ED clinician and thus was not included in the multivariable model in this study.

More aggressive post injury care plans should be given to children at greatest risk of developing PCS in the ED. In addition to routine patient management, communication with schools and provision of coping strategies for family should be
considered in discharge planning. Our finding of a mean of 7.4 days of school missed following injury for 3 out of every 10 children that present with mild TBI underscores the need to explore the role of schools in the rehabilitation of children with mild TBI. Similarly, since investigators have shown that even mild TBI causes significant patient/family anxiety and that family education regarding coping strategies can decrease morbidity, provision of information about these strategies in the acute setting should be studied.

Although this is a large cohort of children selected using a rigorous definition of mild TBI with a high participation rate at 3 months follow-up, some of the variables of interest were not recorded prospectively (e.g., other diagnoses), and others were not recorded in the manner which would be clinically useful (severity indexes of presenting symptoms). The assessment of severity of PCS was only measured at one time point using one tool, which does not allow for understanding the trajectory of recovery. Other contributors to post-injury functioning such as personal and family factors were not included in this cohort. Furthermore, the lack of premorbid data and a control comparison group does not allow for control of these factors. The variation in the person completing the interview, patient or family member, may have affected symptom recall, yet it has been shown that parents and children do have modest agreement reporting PCS symptoms, although children report higher mean levels of symptoms than parents.\textsuperscript{58} We attempted to control for this variation in our analysis by dichotomizing each symptom as increased since injury versus same as prior to injury as opposed to evaluating the severity of the symptom and adding it as a variable in our multivariable model. Lastly, due to the small proportion of patients having S100B
drawn, a conclusion about the clinically utility of this marker for predicting outcome cannot be drawn.

Although signs and symptoms at the time of injury may not accurately predict those children who go on to have PCS on their own, they provide a heuristic for identifying children at elevated risk. Casting a broad net in the ED with increased resources directed at accurate identification and capture of all children with mild TBI will not only ensure accurate incidence rates of the initial mild TBI but will help to clarify the incidence and predictors of disability following injury. Variables found to accurately predict children at risk of clinically significant intracranial injury need to be tested to assess the ability of these rules to predict risk of PCS. Other objective testing at the time of injury, such as measures of reaction time, balance and visual motor coordination may be necessary adjuncts to routine clinical assessment of these children.
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Figure 1. Frequency and Severity of PCS Symptoms.
<table>
<thead>
<tr>
<th>Demographics</th>
<th>Overall n=406</th>
<th>PCS n=119</th>
<th>No PCS n=287</th>
<th>Univariate Odds Ratio (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean years ± SD)</td>
<td>13.2 ± 3.5</td>
<td>12.8 ± 3.6</td>
<td>14.1 ± 3.2</td>
<td>1.11 (1.04, 1.19)</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>61.2</td>
<td>52.9</td>
<td>64.7</td>
<td>0.61 (0.40, 0.95)</td>
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<tr>
<td>Race (% white)</td>
<td>84.5</td>
<td>82.4</td>
<td>85.4</td>
<td>0.80 (0.45, 1.42)</td>
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<td>Ethnicity (% non-Hispanic)*</td>
<td>94.1</td>
<td>93.8</td>
<td>94.2</td>
<td>0.93 (0.37, 2.34)</td>
</tr>
<tr>
<td>Insurance (% public/self)</td>
<td>27.1</td>
<td>32.8</td>
<td>24.7</td>
<td>1.48 (0.93, 2.37)</td>
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<tr>
<td>Prior TBI (% yes)</td>
<td>29.7</td>
<td>29.4</td>
<td>29.8</td>
<td>0.98 (0.61, 1.57)</td>
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<tr>
<td>Severe MOI (% yes)</td>
<td>39.2</td>
<td>45.4</td>
<td>36.6</td>
<td>1.44 (0.93, 2.22)</td>
</tr>
<tr>
<td>Mode of Arrival (% EMS)</td>
<td>53.2</td>
<td>56.9</td>
<td>51.6</td>
<td>1.24 (0.80, 1.91)</td>
</tr>
<tr>
<td>Other Diagnoses</td>
<td>68.7</td>
<td>73.1</td>
<td>66.9</td>
<td>1.35 (0.84, 2.16)</td>
</tr>
<tr>
<td>ED Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCS &lt; 15 (% yes)</td>
<td>4.9</td>
<td>6.7</td>
<td>4.2</td>
<td>1.65 (0.66, 4.15)</td>
</tr>
<tr>
<td>LOC (% yes)</td>
<td>53.0</td>
<td>58.8</td>
<td>50.5</td>
<td>1.4 (0.91, 2.16)</td>
</tr>
<tr>
<td>Headache (% yes)</td>
<td>70.6</td>
<td>83.2</td>
<td>65.4</td>
<td>2.62 (1.53, 4.49)</td>
</tr>
<tr>
<td>Amnesia (% yes)</td>
<td>49.4</td>
<td>49.6</td>
<td>49.3</td>
<td>1.01 (0.66, 1.55)</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>------------------</td>
</tr>
<tr>
<td>Nausea/Vomiting (% yes)</td>
<td>37.3</td>
<td>43.7</td>
<td>34.6</td>
<td>1.47 (0.95, 2.27)</td>
</tr>
<tr>
<td>Other MS Changes (% yes)</td>
<td>91.8</td>
<td>91.6</td>
<td>92.0</td>
<td>0.95 (0.44, 2.07)</td>
</tr>
<tr>
<td>CT in ED (% performed)</td>
<td>54.2</td>
<td>63.0</td>
<td>51.0</td>
<td>0.61 (0.40, 0.95)</td>
</tr>
<tr>
<td>Abnormal CT (% vs CT Normal or Not Done)</td>
<td>3.4</td>
<td>3.4</td>
<td>3.5</td>
<td>1.04 (0.31, 3.38)</td>
</tr>
<tr>
<td>Analgesics in ED (% yes)</td>
<td>55.4</td>
<td>65.6</td>
<td>51.2</td>
<td>1.81 (1.16, 2.82)</td>
</tr>
<tr>
<td>Mild TBI D/C Instructions (% yes)</td>
<td>63.1</td>
<td>63.1</td>
<td>36.9</td>
<td>0.73 (0.47, 1.15)</td>
</tr>
<tr>
<td>Disposition (% admitted)</td>
<td>10.4</td>
<td>17.8</td>
<td>7.4</td>
<td>2.72 (1.42, 5.20)</td>
</tr>
</tbody>
</table>

### 3-Month F/U Questions

<table>
<thead>
<tr>
<th>Interviewee (% self)</th>
<th>35.7</th>
<th>55.5</th>
<th>44.5</th>
<th>1.70 (1.10, 2.64)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analgesics at Home (% yes)</td>
<td>56.9</td>
<td>70.6</td>
<td>51.2</td>
<td>2.29 (1.45, 3.51)</td>
</tr>
</tbody>
</table>

**Days of School Missed (mean ± SD)**
- 3.7 ± 9.0 (range 0-75)
- 2.2 ± 5.1
- 7.4 ± 4.9

**In Process/Intent to Sue (% yes)**
- 9.6
- 19.3
- 5.6

Table 2. Predictors of PCS in Children after Mild TBI Using Logistic Regression