Baseline Predictors of Fatigue 1 Year After Mild Head Injury

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Objective: To compare reports of fatigue 12 months after minor trauma by participants with mild head injury (MHI) with those with other injury, and identify injury and baseline predictors of fatigue.

Design: An inception cohort study of participants with MHI and other nonhead injuries recruited from and interviewed at the emergency department (ED), with a follow-up telephone interview at 12 months.

Setting: Level II community hospital ED.

Participants: Participants (n = 58) with MHI and loss of consciousness (LOC) of 30 minutes or less and/or posttraumatic amnesia (PTA) less than 24 hours, 173 with MHI but no PTA/LOC, and 128 with other mild nonhead injuries. Inclusion criteria: age 18 years or older, within 24 hours of injury, Glasgow Coma Scale score of 13 or higher, and discharge from the ED.

Interventions: Not applicable.

Main Outcome Measure: Medical Outcomes Study 36-Item Short-Form Health Survey Vitality subscale.

Results: Significant predictors of fatigue severity at 12 months were baseline fatigue, having seen a counselor for a mental health issue, medical disability, marital status, and in some stage of litigation. Injury type was not a significant predictor.

Conclusions: Fatigue severity 12 months after injury is associated with baseline characteristics and not MHI. Clinicians should be cautious about attributing persisting fatigue to MHI without comprehensive consideration of other possible etiologic factors.

Key Words: Fatigue; Rehabilitation.

Fatigue is among the most frequently cited problems by individuals with either MHI (1-6) or other minor injury. (7,8) Occurrence rates for fatigue among MHI groups have ranged from 21% to 91%, with symptom persistence reported to be from 2 weeks to as long as 5 years. (1-3,5,9-14) The literature regarding fatigue among individuals with other minor injury is limited, but reports have suggested occurrence rates of 31% to 35%. (7,8) There is considerable overlap on reported rates of fatigue across these 2 populations. However, review of available studies that specifically include data concerning fatigue as a symptomatic expression of MHI revealed methodologic and conceptual issues that prevent formulation of clear and coherent conclusions. These issues are reviewed.

Issues Concerning Type of Control Group

Studies that compared MHI with healthy controls have generally found a higher incidence of fatigue for the MHI groups. (4,5,10) Similar findings were reported in studies that compared participants with mild to severe traumatic brain injury to a noninjured group. (2,3,14) However, it is not possible to determine from such comparisons whether fatigue is attributable directly to head injury, to trauma in general, or independently to both types of injury mechanisms. A more appropriate comparison group would be participants who have had other (ie, nonhead) injuries.

When an other-injury control group has been reported, results were more varied than for studies that only used healthy controls. For example, Stulemeijer et al (9) found more participants with MHI reporting fatigue compared with those with ankle or wrist distortions (32% vs 12%). In contrast, Kraus et al (3) reported very similar occurrence rates between MHI and an other-injury group (42.6% and 43.0%, respectively). In this study, a variety of nonhead injuries was sustained by the comparison group. These included fractures, contusions, or lacerations to the extremities, chest, and abdomen; sprains or strains to the neck or back; and facial contusions or lacerations. Ponsford et al (15) showed higher fatigue frequency ratings at 1 week postinjury for MHI participants than a comparison group with unspecified minor injuries, but not at 3 months. These findings raise concerns about whether fatigue is reliably and specifically associated with MHI.

List of Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AIS</td>
<td>Abbreviated Injury Scale</td>
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<tr>
<td>ANOVA</td>
<td>analysis of variance</td>
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<td>ED</td>
<td>emergency department</td>
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<td>GOAT</td>
<td>Galveston Orientation and Amnesia Test</td>
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<td>ISS</td>
<td>Injury Severity Score</td>
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<td>LOC</td>
<td>loss of consciousness</td>
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<tr>
<td>MHI</td>
<td>mild head injury</td>
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<td>MTBI</td>
<td>mild traumatic brain injury</td>
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<td>PCS</td>
<td>postconcussion syndrome</td>
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<td>PTA</td>
<td>posttraumatic amnesia</td>
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<tr>
<td>SF-36</td>
<td>Medical Outcomes Study 36-Item Short-Form</td>
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Health Survey
Issues Concerning the Use of Cross-Sectional and Descriptive Survey Designs

Studies that have used cross-sectional\textsuperscript{5,9} or descriptive survey designs\textsuperscript{10,11} have reported fatigue at specific intervals after minor head injury, but were not able to describe the process of either symptom progression or resolution over time. Ponsford et al\textsuperscript{15} is the only study, to our knowledge, that prospectively followed fatigue for both patients with MHI who were evaluated in the ED and discharged without admission, and other injury participants, with follow-up phases at 1 week and 3 months postinjury. Other prospective studies of fatigue among head injury of varying severity, including MHI, have had limitations such as not reporting other injury controls,\textsuperscript{12} only following the MHI group over time, but not the control group,\textsuperscript{12} and not having baseline or early measures for either group to demonstrate change over time.\textsuperscript{12}

Studies that have investigated outcome measures other than fatigue have followed participants for up to 1 year post-MHI.\textsuperscript{14-18} The methodologic approach used by these studies serves as a model, suggesting that a prospective design with a nonhead injury control and follow-up at 1 year or longer would be ideal. Such a design would be more likely to reliably assess (1) whether fatigue persists beyond the time of expected recovery, regardless of injury type, and (2) whether the incidence or severity of persisting fatigue for MHI groups is greater than for other injury groups.

Issues Concerning Mediators and Moderators of Fatigue

Studies that investigated post-MHI fatigue have often included demographic variables as correlates of interest. Several of these studies have shown that age and sex were not associated with fatigue after MHI\textsuperscript{9} or head injury of varying severity.\textsuperscript{11,12,14,19} However, Cantor et al\textsuperscript{13} have reported an effect for sex across both head injury and no injury control groups. The relationship between education and fatigue is less clear. In one study, educational level was not significantly related to fatigue,\textsuperscript{9} but in another, fatigue was predicted by higher education.\textsuperscript{14}

The impact of postinjury functional changes on persistence of symptoms has also been widely investigated. A recent well-designed study\textsuperscript{20} of MHI among soldiers after deployment to Iraq found that MHI no longer significantly predicted persistent symptoms, including fatigue, after accounting for postinjury depression and posttraumatic stress disorder. The authors suggested that the higher rates of physical and postconcussion symptoms reported by the participants with MHI were mediated by decline in psychologic health. Similarly, other studies have found postinjury anxiety and depression,\textsuperscript{15,16,21} decline in social activity,\textsuperscript{22,23} and health-related quality of life\textsuperscript{13} to be associated with fatigue.

These studies are distinctive because they report the impact on outcome of changes in functioning subsequent to the injury itself, rather than participant characteristics that were already present at time of injury. However, identifying preinjury characteristics associated with fatigue is also important in order to screen patients who, at the time of injury, might already be at risk for persisting fatigue. There are studies that have implicated the role of these preinjury factors for head injury–related outcomes other than fatigue. For example, the study by Dikmen et al\textsuperscript{24} of hospitalized patients with MHI and other trauma controls showed that demographic variables and pre-existing conditions were predictors of performance on neuropsychologic tests, more so than having had a head injury. Other studies have reported associations between, on one hand, pre-injury health status including physical and mental health, pain, substance abuse, and prior head injury and, on the other hand, a variety of head-injury related outcomes such as postconcussive symptoms, cognitive functioning, disability, and employment.\textsuperscript{25-31} However, in our review, no indicators of preinjury functioning other than demographic variables have been investigated as predictors, mediators, or moderators of fatigue.

Issues Concerning Inconsistency in Terminology and Criteria for Determining Mild Head Injury

The terms mild traumatic brain injury, mild head injury, and concussion have been used almost interchangeably in the literature. Kay et al\textsuperscript{32} recommended making a distinction between MTBI and MHI, so that MHI refers to any trauma to the head and face, while MTBI refers to a MHI with damage to the brain. McLean et al\textsuperscript{33} recommended using neutral terms because of the uncertainty of pathogenesis of symptoms after head injuries (eg, minor head injury rather than MTBI) and descriptive rather than definitive classification terms. Most commonly, however, physical evidence of brain injury is not obtained in MHI. Therefore, brain injury must be deduced using criteria such as presence and length of LOC or PTA and symptomatic signs of neurologic or neuropsychologic dysfunction.\textsuperscript{34,35} Cases involving 1 or a combination of these criteria most often tend to be methodologically grouped together under the general category of MTBI, often without consideration of the degree to which the extent and number of such symptoms might reflect injury severity.

Consistent with these concerns, Dikmen et al\textsuperscript{36} and Rohling et al,\textsuperscript{37} in their replication of Dikmen’s\textsuperscript{36} study, reported a dose-response relationship between head injury severity and residual cognitive impairment. For example, the Dikmen\textsuperscript{36} study demonstrated that the mildest injury subgroup, as defined by “time to follow commands” of less than 1 hour, a proxy for coma length, had considerable overlap with trauma controls on various neuropsychologic measures. However, differences between the study groups became more pronounced with increasing head injury severity. Hoge et al,\textsuperscript{29} although they used the term MTBI, also deliberately classified head injury participants into 2 distinct groups based on presence or absence (ie, only altered mental status) of reported LOC, comparing each of these groups separately with a control condition of other injury. Although the study does not specifically report statistical inferential tests of differences between the 2 head injury groups on physical and other postconcussion symptoms (table 2, p 458),\textsuperscript{20} visual inspection of the reported data do suggest more symptomatic complaints among participants with LOC than those with only altered mental status. Therefore, we further examined differences between the 2 Hoge et al\textsuperscript{29} MHI groups by performing multiple chi-square analyses of the percentage occurrence by group of each reported postinjury symptom. These analyses revealed statistically significant differences between the MTBI groups for 5 of the 19 reported symptoms, including headache, chest pain, heart pounding, constipation, and fatigue. These apparent relationships, consistent with the earlier reports by Dikmen et al\textsuperscript{36} and Rohling et al,\textsuperscript{37} suggest a constellation of dose-response effects for even MHI that would not otherwise be evident based on analysis of a combined group, regardless of severity.

Overview of the Present Study

The current literature review presents evidence that fatigue is a persisting symptomatic concern after MHI, but suggests the hypothesis that fatigue is not a response specific to MHI itself.\textsuperscript{39} For the present study, consistent with our review, several methodologic decisions were made to test this hypo-
ess. First, we compared reports of fatigue by participants with MHI to those with other injuries. Second, data are reported from collection waves at baseline (ie, in the ED) and prospectively at 12 months after trauma. Data were also collected at 1 month and 3 months postinjury, but are not reported here because the focus of the present report is specifically assessment of long-term outcome relative to baseline status. Third, the term MHI is used rather than MTBI both for its more neutral connotation and because no medical information was available in our data set about whether demonstrable damage to the brain had actually occurred. For the study from which the present data were derived, most cases were considered medically too mild even to entertain imaging studies based on ED presentation, or when such studies were available (n = 88), no acute accident-related intracranial lesions were found. However, as a technical consideration, it should be noted that there are strong reasons, based on neuropsychologic findings, not to consider participants with demonstrable acute lesions as even having sustained injuries classifiable as mild. For this reason, had such cases been identified among the present sample, they would have been excluded from the study. Fourth, the current method differentiates MHI status based on presence or absence of brief LOC and/or PTA, so that a possible dose-response relationship between MHI and fatigue can be examined. Finally, this study explores both injury and preinjury factors that may additionally or alternatively account for persisting fatigue.

METHODS
Data for this study were derived from a larger dataset that primarily investigated PCS and other outcomes for an ED-based prospective/inception cohort of patients with minor injury. Initial findings were reported by McLean et al. The study protocol was approved by the Institutional Review Boards of the University of Michigan Medical School, Saint Joseph Mercy Health System, and the Michigan Public Health Institute.

Participants
The sample size was determined based on estimates of frequency of PCS for MHI and non-MHI groups. A study of ED patients with MHI and a control group of patients with minor orthopedic injuries reported frequencies of PCS for the MHI group of 58% at 1 month, 43% at 3 months, and 25% at 6 months. We assumed a frequency of 58%, a precision of ±5%, and an alpha of 0.10, and estimated sample sizes at 264 for MHI and 243 for non-MHI.

Recruitment was accomplished in several stages, each of which successively determined eligibility for the study. Patients were recruited who presented directly to the ED within 24 hours of minor injury, regardless of method of transport. The ED site was a Level II trauma center at a community teaching hospital. Patients were recruited 7 days a week and 8 hours a day over a 15-month period. Shifts were sampled as follows: 70% of the shifts from 3 PM to 11 PM, 20% from 7 AM to 3 PM, and 10% from 11 PM to 7 AM. Based on prior review of ED admission patterns conducted by a subgroup of the authors (C.U.T.-S., C.L.T., M.L.B.), these shift sample percentages were roughly representative of the frequency distribution of ED trauma patients when stratified by time of arrival.

Patients were initially identified as potential participants based on presenting information in the ED, including the following: age 18 years or older, within 24 hours of injury, Glasgow Coma Scale score of 13 or higher, did not meet the institution’s criteria for activation of the adult trauma team, and were to be discharged directly from the ED. Exclusion criteria were transfer from another hospital, inability to speak English, being incarcerated, medical evaluation resulting in admission, evidence of still being in a state of PTA at the time of recruitment, assessed LOC of 30 minutes or more, or LOC not attributable to trauma. Based on these criteria, 945 patients were invited to participate.

Eligible patients were then assessed to determine if they were competent to provide informed consent. Criteria were Mini-Mental State Examination of 18 or higher and the ability to describe to the research assistant the essential elements of the study. Of the 945 patients invited to participate, 535 (56.6%) gave consent. Of the 410 who did not give consent, reasons for refusal were no reason given or recorded (44%), physical symptoms preclude participation (22%), and concern that participation would delay discharge (12%). Consecutive participants were next interviewed to determine assignment to study groups.

Head injury groups. Patients were assigned to one of the head injury groups based on self-report and evidence in the medical record of having sustained a head injury. All discrepancies were resolved by the attending physician or nurse. Patients with a confirmed head injury and LOC of 30 minutes or less and/or resolved PTA of any duration were assigned to a head injury with PTA and/or LOC group. Those with confirmed head injury with neither LOC nor PTA were assigned to a head injury only group. To assure sample integrity, the physician or nurse advised about whether or not any reported LOC was potentially attributable to medical conditions independent of head injury. The GOAT was also administered to ensure that participants were not currently in a state of PTA, and participants were excluded if they scored below 76. Based on these combined procedures, a total of 28 participants were excluded from the study, 11 because of eventual hospital admission, 4 because of primary language other than English, 2 because of failure to obtain or record confirmation of head injury status from the treating physician, 1 for a GOAT score below the study criterion, and 10 based on subsequent discovery of exclusion criteria after meticulous re-examination of participant records.

Other injury group. Participants confirmed to have no head injury were assigned to the other injury group. Three participants in this group were excluded from the analyses because of reported LOC or PTA despite not having had documented head trauma. The most common injuries sustained by participants in this group included sprains (25%) to the extremities, neck, and back; contusions (24%) or lacerations (16%) to the extremities or upper body; and closed fractures (21%) to the extremities, vertebra, or ribs. The remaining types of injuries included shoulder dislocation, crushing injuries to fingers, minor eye injury, and burn to hand.

The final sample size at the ED was 504 participants, with 94 participants in the head injury with PTA and/or LOC group, 245 in the head injury only group, and 165 in the other injury group. The sample size at 12 months was 359, with an overall retention rate of 71.2%. Figure 1 illustrates the procedures for determining group membership, and figure 2 summarizes the sampling and retention data.

Measures
Items and measures were selected from the larger dataset, to be used as the following: (1) the dependent fatigue variable, (2) covariates of fatigue, and (3) baseline predictors of fatigue at 12 months. For the predictor variables, 4 data types were used: (1) preinjury health status variables, (2) medical variables including information regarding diagnosis and injury characteristics, (3) demographic variables, and (4) a derived dichotomous variable addressing litigation status. A description...
follows of all variables. They are organized based on their respective roles in the various analyses.

**Sample characteristics.** Demographic and injury variables were used to characterize the sample subgroups. Age, sex, education, marital status, employment status, and ethnicity were obtained from the structured interview and cross-validated against the medical record where possible. Cause of injury and injury severity as indicated by the ISS were obtained from medical records. The ISS is an index of anatomical injury that provides an overall score for patients with multiple injuries. Each injury is assigned an AIS score, which ranges from 1 to 6, with 1 being minor, and 6 being lethal or unsurvivable. The AIS score for each injury is allocated to 1 of 6 body regions. The ISS is defined as the sum of squares of the highest AIS score in the 3 most severely injured body regions. The ISS ranges from 0 to 75.

**Primary outcome.** Fatigue at 12 months was assessed with the 4-item SF-36 Vitality subscale, a component of the SF-36, which was administered in full. Consistent with the standard instructions for this measure, participants were asked to "please give the 1 answer that comes closest to the way you were feeling during the past month." Two of the 4 subscale items concern energy (eg, "How much of the time during the past month did you have a lot of energy?") and 2 concern...
fatigue (eg, “How much of the time during the past month did you feel worn out?”) Each item is rated on a 6-point scale ranging from 1 (all of the time) to 6 (none of the time). The 2 items reflecting energy are reverse-scored. Low scores on the Vitality subscale indicate more fatigue—that is, less vitality. Scores for the SF-36 Vitality subscale administered at 12 months (as well as the same subscale administered at baseline) were converted to T scores for ease of interpretation. The Vitality subscale has good internal consistency (Cronbach $\alpha=.86$). Validity of the Vitality subscale has been established with multiple clinical populations. The Vitality subscale has also specifically distinguished between MHI and healthy or no disability comparison groups. Covariates. The 4-item SF-36 Vitality subscale was administered at baseline using the same scoring procedures as described for the 12-month administration of the subscale. The slightly modified instruction was, “Please give the answer that comes closest to the way you were feeling during the month prior to your current injury.” This covariate was used to control for possible response bias resulting from repeated use of the
same instrument. By introducing baseline fatigue as a covariate, the relationship between the predictors and fatigue at 12 months could be more accurately determined. Litigation status at 12 months was also added as a covariate because it has been consistently found to be associated with persistent symptoms after MHI.\textsuperscript{49,50} Litigation status was broadly determined as positive if any of the following were true: the participant was actively involved in litigation, had received services from a lawyer or a paralegal, had consulted with an attorney, or was considering consulting an attorney, regarding the injury.

**Independent or predictor variables.** Participants were classified into 1 of 3 injury groups: head injury with PTA and/or LOC, head injury only, and other injury. This variable was used as a dummy grouping variable, predicting the primary outcome measure.

Other predictors of fatigue at 12 months were cause of injury (ie, motor vehicle crash vs nonmotor vehicle crash), demographic characteristics (age, sex, education, employment status, marital status), and baseline health status. Having a medical disability (regardless of cause) was used as the indicator of baseline health status and was assessed with a question regarding reasons for not working. Additional components of baseline health status were assessed through responses to single questions regarding history of psychologic or mental health problems. These questions were, “Have you ever seen a counselor, such as a psychologist or psychiatrist for a mental health issue?” and “Have you ever been treated for a drug or alcohol problem?”

**Procedure**

The baseline interview, approximately 30 minutes, was administered, if possible, between medical examinations and other treatments. At the conclusion of each interview, contact information was verified for follow-up. The participants were subsequently interviewed by telephone at 1, 3 (both not reported for this study), and 12 months. Halfway between 3 and 12 months, participants were contacted by mail to remind them about an impending telephone follow-up interview at 12 months. At each of the follow-up time points, a maximum of 10 attempts was made to contact each participant. They were given $25 after completion of the interview at the ED, 1 month, and 3 months, and $75 at 12 months to maximize retention rates.

**Data Analysis**

Statistical analyses were performed with SPSS version 14.\textsuperscript{a} For all analyses, 2-tailed tests of significance with alpha level of .05 were used.

Differences between study groups in categorical baseline and injury characteristics (eg, sex, employment, cause of injury) and fatigue status at 12 months were assessed with Pearson chi-square tests of independence. The phi coefficient was calculated as an estimate of effect size. Group differences in the main outcome variable, SF-36 Vitality subscale administered at 12 months, and interval-level baseline variables (eg, age, ISS, SF-36 Vitality subscale administered at baseline) were assessed with a series of univariate ANOVA, with Bonferroni correction to adjust for multiple pairwise comparisons. Partial eta squared was the measure of effect size.

Hierarchical linear regression analysis was done to identify variables associated with fatigue severity at 12 months. These variables included selected preinjury characteristics as well as injury group membership. Condition indices and variance proportions were examined to assess for possible multicollinearity between predictor variables.

**RESULTS**

**Participant Baseline Characteristics**

Pearson chi-square tests of independence and ANOVA (where appropriate) indicated no significant differences between the groups for sex, race, education, marital status (table 1), and ISSs. For the entire study sample, more than half of the participants were female (57%), 80% were white, 93% had at least high school education, and 45% were married. ANOVA yielded no significant group difference in means ISSs (F = .071, P = .931), with the scores further verifying the minor nature of the injuries for each of the groups (head injury with PTA and/or LOC: mean ± SD, 2.00 ± 1.58; head injury only: mean ± SD, 1.91 ± 2.06; other injury: mean ± SD, 1.89 ± 1.50).

The 3 study groups differed significantly in cause of injury, employment status, age, and baseline Vitality score. Pearson chi-square analysis yielded a significant difference between groups in cause of injury. More of the head injury with PTA and/or LOC (37.9%) and head injury only (33.5%) groups and fewer of the other injury group (18.8%) sustained their injuries from a motor vehicle collision (χ² = 10.51, P = .005, ϕ coefficient = .17). Employment status was also significantly different for the study groups. More of the other injury group were employed at the time of injury (81.3%) compared with a lower proportion for the head injury with PTA and/or LOC (67.2%) and head injury only (69.4%) groups (χ² = 6.58, P = .037, ϕ coefficient = .14).

ANOVA revealed a significant difference in age (F₂,₃₅₆ = 5.525, P = .004; partial χ² = .03), with the head injury only group significantly older than the head injury with PTA and/or LOC (Bonferroni-corrected P = .016) and other injury groups (Bonferroni-corrected P = .030). Mean age and SDs for each group are as follows: head injury only, 43.0 ± 19.5; head injury with PTA and/or LOC, 35.7 ± 16.17; and other injury, 37.8 ± 14.47. The 3 groups were also compared on the SF-36 Vitality subscale administered at baseline (F₂,₃₅₆ = 3.83, P = .023; partial χ² = .02). Mean SF-36 Vitality subscale administered at baseline, expressed as T scores, and SDs for the head injury only group were 43.0 ± 19.5; head injury with PTA and/or LOC, 35.7 ± 16.17; other injury, 37.8 ± 14.47.

**Table 1: Characteristics of Study Sample (% of Cases a Category a Group)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>HI-P/L (n = 128)</th>
<th>HIO (n = 173)</th>
<th>OI (n = 128)</th>
<th>Total (n = 359)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>55.2</td>
<td>59.0</td>
<td>56.3</td>
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<td>33.5</td>
<td>18.8</td>
<td>29.0</td>
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</table>

NOTE. Partial total percentages may not equal 100% because of rounding.

Abbreviations: HI-P/L, MHI with PTA and/or LOC; HIO, MHI without PTA or LOC; OI, mild nonhead injury.

* P based on Pearson χ² tests of independence.
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injury with PTA and/or LOC, head injury only, and other injury groups, respectively, were 52.8±9.53, 50.4±10.48, and 53.4±8.64. The head injury only group scored significantly lower (ie, had greater fatigue severity) than the other injury group (Bonferroni-corrected P = .026). No other pairwise comparisons were significant.

Participants lost to follow-up (n = 145, 28.8%) were compared with those who completed the study. A larger percentage (38.3%) of the head injury with PTA and/or LOC group had no follow-up data compared with 29.4% of the head injury only and 22.4% of the other injury groups (χ² = 7.45, P = .024, φ coefficient = .12). In addition, more of the participants with the following characteristics were lost to follow-up: males, 18 to 34 years old (youngest age group classification), with less than high school education, and whose cause of injury was assault.

Group Differences in Fatigue Severity at 12 Months

The primary objective of this study was to assess differences in reported fatigue between participants with and without head injury 12 months after minor trauma. As an initial attempt to determine these differences, scores on the SF-36 Vitality subscale administered at 12 months for the 3 groups were compared. Mean scores of the SF-36 Vitality subscale administered at 12 months, expressed as T scores, and SDs for the head injury with PTA and/or LOC, head injury only, and other injury groups, respectively, were 52.3±12.22, 49.6±11.83, and 53.0±10.37. There were significant differences between the groups (F₂,₃₅₆ = 3.77, P = .024; partial η² = .02). Pairwise comparisons revealed the head injury only group to have a lower mean score at 12 months than the other injury group (Bonferroni-corrected P = .027). No other pairwise comparisons were significant.

Contributions of Injury Status and Preinjury Characteristics to Fatigue Severity

Because of the group differences noted for baseline measures, as summarized in the section on participant baseline characteristics, including the SF-36 Vitality subscale administered at baseline, and the negligible effect size for injury group, a hierarchical regression analysis was performed in order to determine significant predictors of the SF-36 Vitality subscale administered at 12 months. This analysis successively introduced 3 blocks of variables. The first block included the covariates SF-36 Vitality subscale administered at baseline and litigation status at 12 months, which were introduced to remove the possible confounding effects of these 2 variables. The second block included cause of injury, demographic, and baseline health status variables. Finally, the third block included head injury status to verify its contribution to prediction of fatigue after accounting for these variables. The regression model is summarized in Table 2. Examination of the collinearity diagnostics indicated that multicollinearity was not an issue (maximum condition index = 18.2, maximum variance proportion = .35).

As expected, the SF-36 Vitality subscale administered at baseline was a significant predictor and accounted for the largest proportion of the variance of SF-36 Vitality subscale administered at 12 months. It was not possible to determine from our data whether the variance in SF-36 Vitality subscale administered at 12 months accounted for by the SF-36 Vitality subscale administered at baseline is exclusively attributable to a substantive relationship between the SF-36 Vitality subscale administered at baseline and the SF-36 Vitality subscale administered at 12 months (ie, that fatigue at 12 months is clinically associated with reports of fatigue at baseline) or to response bias attributable to use of the same instrument. Although our impression is that the relationship is, in fact, substantive, not artifactual, we wanted to extract from the regression analysis both of these possible sources of variance in order to establish the association between the SF-36 Vitality subscale administered at 12 months and other baseline variables more clearly. In addition, being involved in some stage of the litigation process at 12 months was also associated with fatigue severity. After accounting for the contribution of SF-36 Vitality subscale administered at baseline and litigation status at 12 months, the significant predictors of SF-36 Vitality subscale administered at 12 months were marital status (ie, separated, divorced, or widowed), having a medical disability, having seen a counselor for a mental health issue, and being in some stage in the process of litigation. Having had a head injury was not significantly associated with fatigue severity at 12 months after accounting for baseline characteristics.

DISCUSSION

This study examined rates and severity of fatigue at 12 months postinjury for participant groups (evaluated in and discharged directly from the ED) characterized by 2 degrees of MHI severity, compared with a group having other mild non-head injuries. The data yielded several critical findings.

First, in contrast with earlier work examining the relationship between MHI and fatigue, our findings indicate that fatigue is not a significant problem for the current sample of very mildly injured participants when assessed 12 months after injury. Normative scoring of the SF-36 Vitality subscale indicates that mean Vitality scores for all the study groups approximate the population mean for this measure. In addition, SF-36 Vitality subscale scores for this study’s MHI subgroups are higher than what has been reported in studies using the same measure at 3 to 4 months and at least 1 year after MHI. This difference may be a result of the very mild nature of injury severity among our cohort compared with samples in other studies. For example, our MHI subgroups had lower mean ISS scores and the head injury with PTA and/or LOC group had shorter mean PTA length than the MHI sample of Paniak et al.51 Other studies reporting fatigue among participants with MHI also included hospitalized cases in their sample,59 in contrast with our nonhospitalized cohort.

Second, compared with the results of the above referenced studies,4-9,43-51 our findings of less fatigue for a nonhospitalized MHI cohort might suggest that injury severity affects later fatigue, even for head injuries of the mildest kind. However, despite this possibility, comparisons of our 3 study groups yielded no significant difference between the MHI subgroups in fatigue severity at 12 months. Although the less severe head injury group (ie, with no accompanying LOC or PTA) did report more fatigue than the other injury group, our regression analysis indicates that this seemingly paradoxical finding is a result of differences in initial participant characteristics. Specifically, our findings indicate that poor medical health, mental health, and marital status at baseline (being widowed, divorced, or separated), and not type of minor injury, were the significant predictors of fatigue severity at 12 months. Regarding marital status, post hoc examination of the data further indicates that significantly more of those who were widowed, divorced, or separated were living alone at the time of injury, even compared with those who reported being single at the time of injury (χ² = 66.9, P = .001). Although we do not have data to support a specific theoretical interpretation of this finding, the data do suggest that disrupted social support is a critical variable that affects reports of fatigue and, hypothetically, feelings of general well being.
This finding, that preinjury status, rather than injury type, predicts later fatigue severity, emphasizes the importance of including preinjury characteristics when examining the etiology of fatigue after MHI or, more generally, mild trauma of any kind. Our data suggest that in the absence of information about baseline functioning, fatigue may be misattributed to the occurrence of an injury when, in fact, the persistence of fatigue may simply reflect an individual’s health and psychosocial status as of the time they report to the ED.

Third, involvement in the litigation process is an important covariate of fatigue severity. This finding represents partial support for the consistently reported role of compensation issues in poor recovery after MHI.\(^59\)\(^,\)\(^60\)

**Study Limitations**

The generalizability of findings from the present sample of nonhospitalized cases to the general MHI population may be limited. Comparison of our findings to other studies raises the possibility that injury severity may, in fact, influence fatigue (although we did not find such a difference specifically for our sample of very mildly injured participants). This issue could be clarified by studies that incorporate samples of participants for comparison across a broader range of injury severity subclasses.

Another limitation of the present study is the possibility of sample bias, as reflected by several baseline differences between the study groups. First, the higher percentage of participants with MHI with injuries from a motor vehicle crash may be indicative of more severe trauma. However, this appears unlikely because the ISSs indicate very minor injury severity for all groups. Second, the higher percentage of employed participants in the other injury group may reflect better functioning for this group than the MHI subgroups. However, if higher rates of employment among other injury participants resulted in less fatigue, there would be a significant difference in reported fatigue between the other injury and PTA/LOC groups. This was not the case. Third, the head injury only group reports poorer baseline health status than the other 2 groups, as well as greater fatigue. The mechanisms responsible for these findings are unclear and require further investigation. However, there are several hypotheses worth considering. Individuals with characteristics such as poor baseline health may be more likely to seek emergency care after minor head injury if they are sensitized to the possibility that additional insults might compromise their functional status. Additionally, as suggested by Mittenberg et al.,\(^61\) some individuals may misattribute baseline levels of fatigue to their injury and continue to do so over longer periods.

Finally, a third study limitation is the relatively high rate of observed attrition. The initial refusal rate at the ED was large (43%). It is possible that refusal to participate is a nonrandom phenomenon that resulted in a biased sample. Unfortunately, we were unable to verify the possibility of such a bias. The absence of information from those who refused to participate prevented analysis of initial differences between consenting and nonconsenting patients. Attrition at 12 months may be an additional source of bias. We have no data about the reasons participants had for dropping out. It is equally plausible that participants dropped out because they had recovered or, conversely, were experiencing more problems.

**CONCLUSIONS**

Our findings indicate that fatigue was not a significant problem 12 months after minor trauma for nonhospitalized participants with mild head or other injury and that there were no significant differences between the study groups in fatigue severity after accounting for baseline characteristics. The finding that baseline characteristics are significant predictors of fatigue severity at 12 months suggests that it may be inadvisable to attribute persisting fatigue to MHI without careful and comprehensive consideration of other possible etiologic factors. The compensation context is additionally an important issue affecting reported recovery after MHI that must be considered. The treatment of patients who present with such prob-

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**Table 2: Hierarchical Regression Analysis Predicting SF-Vitality Score at 12 Months**

<table>
<thead>
<tr>
<th>Summary of Coefficients for Model 3</th>
<th>Part r</th>
<th>P</th>
<th>B</th>
<th>SE of B</th>
<th>(\beta)</th>
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<tr>
<td>Constant</td>
<td>34.444</td>
<td>5.841</td>
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<td></td>
<td></td>
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<tr>
<td>Block 1: covariates</td>
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<tr>
<td>12-mo litigation</td>
<td>-.088</td>
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<td>-6.670</td>
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<td>Baseline SF-Vitality</td>
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<td>.498</td>
<td>0.056</td>
<td>.427</td>
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<td>Block 2: baseline characteristics</td>
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<td></td>
<td></td>
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<tr>
<td>Sex</td>
<td>.013</td>
<td>.762</td>
<td>.660</td>
<td>2.176</td>
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<tr>
<td>Age</td>
<td>-.029</td>
<td>.507</td>
<td>-.056</td>
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<tr>
<td>Education</td>
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<td>Married</td>
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<td>-.070</td>
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<td>Separated/divorced/widowed</td>
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<td>Working</td>
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<td>With medical disability</td>
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<td>Motor vehicle crash</td>
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<td>Block 3: injury groups</td>
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<tr>
<td>HI-P/L (MHI with PTA or LOC)</td>
<td>.012</td>
<td>.792</td>
<td>0.818</td>
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<td>HIO (MHI without PTA or LOC)</td>
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<td>.427</td>
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<th>df</th>
<th>P</th>
<th>Adjusted (R^2)</th>
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<th>F for (R^2) Change</th>
<th>P for (R^2) Change</th>
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<td>.277</td>
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<td>68.91</td>
<td>.000</td>
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<td>.326</td>
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<td>3.55</td>
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<td>.002</td>
<td>0.55</td>
<td>.580</td>
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</table>

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lens may be best shaped by these considerations, including the use of interventions that directly address the baseline issues that affect functioning, rather than the minor trauma itself.

References

Supplier
a. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.