Workplace and non-workplace mild traumatic brain injuries in an outpatient clinic sample: A case-control study

The Harvard community has made this article openly available. Please share how this access benefits you. Your story matters

Citation
Terry, Douglas P., Grant L. Iverson, William Panenka, Angela Colantonio, and Noah D. Silverberg. 2018. “Workplace and non-workplace mild traumatic brain injuries in an outpatient clinic sample: A case-control study.” PLoS ONE 13 (6): e0198128. doi:10.1371/journal.pone.0198128. http://dx.doi.org/10.1371/journal.pone.0198128.

Published Version
doi:10.1371/journal.pone.0198128

Citable link
http://nrs.harvard.edu/urn-3:HUL.InstRepos:37298379

Terms of Use
This article was downloaded from Harvard University's DASH repository, and is made available under the terms and conditions applicable to Other Posted Material, as set forth at http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA
RESEARCH ARTICLE

Workplace and non-workplace mild traumatic brain injuries in an outpatient clinic sample: A case-control study

Douglas P. Terry¹,²,³,⁴, Grant L. Iverson¹,²,³,⁴, William Panenka⁵,⁶, Angela Colantonio⁷,⁸, Noah D. Silverberg⁹,¹⁰*,

¹ Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston, Massachusetts, United States of America, ² Spaulding Rehabilitation Hospital, Boston, Massachusetts, United States of America, ³ Mass General Hospital for Children™ Sports Concussion Program, Boston, Massachusetts, United States of America, ⁴ Home Base, A Red Sox Foundation and Massachusetts General Hospital Program, Boston, Massachusetts, United States of America, ⁵ British Columbia Neuropsychiatry Program, Vancouver, British Columbia, Canada, ⁶ Department of Psychiatry, University of British Columbia, Vancouver, British Columbia, Canada, ⁷ Department of Occupational Science and Occupational Therapy, University of Toronto, Toronto, Ontario, Canada, ⁸ Toronto Rehabilitation Institute, University Health Network, Toronto, Ontario, Canada, ⁹ Division of Physical Medicine & Rehabilitation, University of British Columbia, Vancouver, British Columbia, Canada, ¹⁰ Rehabilitation Research Program, Vancouver Coastal Health Research Institute, Vancouver, British Columbia, Canada

* noah.silverberg@vch.ca

Abstract

Individuals who are injured in the workplace typically have a greater risk of delayed return to work (RTW) and other poor health outcomes compared to those not injured at work. It is not known whether these differences hold true for mild traumatic brain injuries (MTBI). The present study examined differences associated with workplace and non-workplace MTBI upon intake to a specialty MTBI clinic, their outcomes, and risk factors that influence RTW. Slow-to-recover participants were recruited from consecutive referrals to four outpatient MTBI clinics from March 2015 to February 2017. Two clinics treat Worker’s Compensation claimants and two clinics serve patients with non-work related injuries in the publically funded health care system. Of 273 eligible patients, 102 completed an initial study assessment (M age = 41.2 years, SD age = 11.7; 54% women) at an average of 2–3 months post injury. Participants were interviewed about their MTBI and completed a battery of standardized questionnaires and performance validity testing. Outcomes, including RTW, were assessed via telephone follow-up 4–5 months later. Workplace injuries comprised 45.1% of the sample. The workplace MTBI group had a greater proportion of men and lower education levels compared to the non-workplace MTBI group. The two groups had a comparable post-concussion symptom burden and performance validity test failure rate. Workplace MTBI was associated with greater post-traumatic stress symptoms. Fifteen patients (14.7%) were lost to follow-up. There were no workplace/non-workplace MTBI differences in RTW outcome at 6–7 months post injury. Of the entire sample, 42.5% of patients had full RTW, 18.4% had partial RTW, and 39.1% had no RTW. Greater post-concussion symptom burden was most predictive of no RTW at follow-up. There was no evidence that the workplace and non-workplace MTBI groups had different risk factors associated with prolonged work absence.
Despite systemic differences in compensation and health care access, the workplace and non-workplace MTBI groups were similar at clinic intake and indistinguishable at follow-up, 6–7 months post injury.

Introduction

Approximately 1 in 4 mild traumatic brain injuries (MTBIs) in adults occur at work[1,2]. Across the spectrum of severity, workplace brain injuries are associated with substantial productivity loss, economic burden[3–5], persistent symptoms and occupational disability[1,6]. Considering traumatic injuries of all kinds, patients who are injured at their workplace are at greater risk of delayed return to work (RTW) and other poor health outcomes than those who were injured outside of work[7]. It is not known whether this difference holds for MTBI and which factors account for worse outcomes from workplace injuries. There are several reasons to expect differences between workplace and non-workplace MTBIs. For example, whereas many falls and recreational accidents are non-compensable, patients who are injured at work are legally entitled to compensation[8]. Compensation access is highly predictive of delayed RTW[9,10]. Worker’s Compensation claimants in Canada have substantial rates of suspected symptom exaggeration after MTBI[11,12]. However, compensation access cannot fully account for differences in RTW rates. For example, in New Zealand’s universal entitlement system, where workplace and non-workplace injuries afford the same access to compensation, workplace injuries are associated with a greater risk of delayed RTW, as well as long-term physical and emotional health problems[7].

Differences in patient demographics might contribute to differences between workplace and non-workplace injuries. MTBI is more common in men[13], and this gender gap is wider for workplace injuries (including MTBI)[2,4,14,15], but women are at greater risk for chronic symptoms following MTBI[16–18]. Women more often access health services than men in some settings, but not for a workplace MTBI[19]. Gender and workplace factors may also interact. Traditionally masculine work environments may be less supportive for returning injured workers[20]. MTBI occurs disproportionately in manufacturing, construction, and transportation[2,4,6,15]. These occupations are associated with lower education attainment and decision-making latitude at work, factors that have been previously linked to worse outcomes from MTBI[21–24].

Another factor that may contribute to poor prognosis and delayed RTW after work injury is blame attribution[8,25,26]: who or what the patient perceives is at fault for their injury. Those who are injured at work are most likely to blame equipment or others in the workplace rather than themselves, whereas self-blame is most common in non-workplace injuries[8]. Blame perception regarding work injury is predictive of disability at 6-months post injury[25]. The broader concept of injustice may be more predictive of occupational disability than simply asking injured workers who is at fault[27–30]. In relation to an injury or illness, perceived injustice is a set of beliefs that comprise blame, a sense of unfairness, severity of loss, and that their loss is irreparable[30]. Injured workers who blame their employer may be less inclined to return to that work setting because they feel unsafe. Further, those with a workplace MTBI may face relationship strain related to the increased work burden on co-workers in their absence or feeling retaliated against by their employer/company[31].

Mental health and interpersonal/psychosocial difficulties may also be barriers to returning to work. Posttraumatic stress disorder (PTSD) is a relatively frequent (12–27%) comorbidity
that complicates recovery from MTBI [32]. Even symptoms of post-traumatic stress that are not severe enough to meet full diagnostic criteria magnify the risk of not returning to work at 6–9 months post MTBI [21]. PTSD may be especially common and problematic following workplace MTBI, because workplace injuries in general are associated with more PTSD symptoms than non-workplace injuries and PTSD symptoms, in turn, are associated with delayed RTW [8]. They may be a particular barrier for returning to the same job with the same employer [33], because that would by definition involve exposing oneself to trauma-related triggers.

The primary aim of this study was to compare symptomatic workplace vs. non-workplace patients with MTBIs with respect to their initial presentation to a specialty MTBI clinic and RTW outcomes. A secondary aim was to determine if different risk factors influence RTW in each group. Compared to the non-workplace MTBI group, we predicted that the workplace MTBI group would include a greater proportion of men, have lower education levels, a lower proportion of occupations with high decision-making latitude, stronger perceived injustice beliefs, worse PTSD symptoms, higher rate of symptom invalidity, and lower rate of RTW. We further hypothesized that perceived injustice and traumatic stress symptoms would be more strongly related to RTW status at follow-up in the workplace MTBI group.

**Materials and methods**

**Participants and procedures**

Participants were recruited via consecutive referrals to four outpatient clinics in the Vancouver (Canada) area that specialize in MTBI/concussion rehabilitation from March 2015 to February 2017. Two of these clinics treat Worker’s Compensation claimants, while the other two serve patients with non-work related injuries, in the publicly funded health care system. Participants with work-related MTBIs were referred to clinic by their Worker’s Compensation Board case managers. Participants whose MTBI was not work-related could have been referred by their family physician or specialist, or self-referred. Referrals to these speciality MTBI clinics were initiated because of persistent symptoms or risk factors for persistent symptoms. Patients referred to these clinics are usually on an atypical recovery trajectory and they are considered at risk for long-term symptoms and problems. To be eligible for the study, participants had to be 18–65 years old, have sustained a MTBI within the past six months (based on the World Health Organization Neurotrauma Task Force definition [34]), be fluent in English, and employed prior to the injury. The University of British Columbia Ethics Board, the Vancouver Coastal Health Research Institute, and the Fraser Health Research Institute approved this study. Participation in this research study was voluntary. The measures described below were administered to patients as part of a research battery (i.e., not in usual clinical care). Of the 273 patients who agreed to be contacted for research purposes during the recruitment period, 93 were excluded based on an initial screening phone call (i.e., 44 did not meet MBTI criteria; 26 were injured > 6 months prior; 16 were not employed prior to the injury; 4 were not fluent in English; 3 were > 65 years old) and 40 declined to participate. 140 participants were invited for an initial assessment, but 38 could not be scheduled or did not attend. There were 102 participants who gave written consent for this study and completed the initial study assessment.

Participants were assessed at two time points, when they initially presented to clinic and again 4–5 months following their initial study visit, after undergoing rehabilitation. The initial study assessment occurred 2–26 weeks post injury (M = 12.05; SD = 6.26) and included a standardized semi-structured interview of their demographics (e.g., education, occupation), prior health history (e.g., pre-injury mental health treatment), and MTBI (e.g., self-reported injury characteristics, such as mechanism of injury, loss of consciousness (LOC), amnesia,
confusion/disorientation, co-occurring orthopaedic injury, healthcare utilization, compensation-seeking status]. Based on the participant’s report of their injury, LOC was classified into one of the following mutually exclusive categories: witnessed (i.e., participant learned from another person’s eye witness account that they had an LOC), unwitnessed (i.e., participant inferred that they had an LOC but were not observed by another person to be unresponsive), unknown LOC (i.e., participant stated that they were unsure whether they had an LOC or not), or denied LOC. Medical records were not accessed for the purpose of this study. Further, participants completed several questionnaires (see Measures). The follow-up assessment occurred 21–47 weeks post injury (M = 31.57; SD = 6.05) via telephone. During this follow-up assessment, participants participated in a structured interview about their RTW status. Their answers were classified into three possible outcomes to form our primary outcome variable: (i) Full RTW: Returned to same hours and responsibilities at their pre-injury job, or started a new job with comparable hours/responsibilities; (ii) Partial RTW: Returned to pre-injury job but with reduced hours or responsibilities, or started a new job that is less demanding; or (iii) No RTW: Not working because of the MTBI, other injuries from the same event, or unrelated to injury event. Additionally, at the time of the follow-up assessment, a treating clinician at each site completed a health service utilization summary for each patient (6 summaries missing; 3 workplace MTBI and 3 non-workplace MTBI).

**Measures**

**Injustice Experience Questionnaire (IEQ).** The IEQ[27] is a 12-item questionnaire that assesses perceived injustice associated with injury. This is operationalized as a set of cognitions regarding how individuals view their injury and its consequences, including beliefs about being treated unfairly and suffering unnecessarily as a result of another’s actions. Individual items are rated on a 0–4 scale based on frequency (i.e., “never” to “always”) and summed for the total score (range: 0–48). This scale correlates with symptom chronicity and occupational disability in a variety of health conditions[27,28,30,35,36]. Internal consistency was excellent for this scale in the present sample (Cronbach’s $\alpha = .92$).

**PTSD checklist for DSM-5 (PCL-5).** The PCL-5 is a 20-item questionnaire that assesses symptoms of post-traumatic stress over the past month. Participants rate how much they were bothered by each symptom (0/“not at all” to 4/“extremely”). Total scores range from 0–80. This measure has high reliability and good evidence of convergent and discriminant validity [37,38]. Internal consistency was high for this scale in the present sample (Cronbach’s $\alpha = .94$).

**Brief Pain Questionnaire (BPQ).** The BPQ is a 5-item questionnaire that assesses current pain in the following five bodily regions: the head/skull, neck, chest/abdomen/back, arms/shoulders, and pelvis/legs. Current pain intensity is rated from 0 (none) to 3 (severe) in each bodily region, with a possible score range of 0–15. Internal consistency was acceptable at the initial (Cronbach’s $\alpha = .75$) and follow-up assessments (Cronbach’s $\alpha = .79$).

**Medical Symptom Validity Test (MSVT).** Compensation-seeking status is strongly associated with outcome from MTBI, including RTW[9,39]. People who are involved in compensation claims are more likely to report persistent/exaggerated symptoms[40] and have poor effort during neuropsychological testing[41]. Performance validity testing[42] is a term used for purpose-built tests or embedded validity indicators in a neuropsychological evaluation. Performance validity test failure is independently associated with both compensation-seeking (vs. ineligible for compensation) and workplace (vs. non-workplace) MTBI[43]. The MSVT is sensitive to motivational factors but insensitive to the effects of genuine memory impairment and TBI.[44,45] We used evidence-based cut-off scores on the three “easy” subtests (Immediate Recognition, Delayed Recognition, and Consistency) to identify cases with probable
below-capacity performance. The MSVT has been validated for use in patients with TBI and compares favorably with legacy instruments\cite{46–49}.

**Self-prognosis rating.** At the initial study assessment, participants were asked a single question about how they expected their recovery would progress. Similar self-prognosis ratings have been shown to have prognostic value in both MTBI\cite{50–52} and mixed traumatic injury samples\cite{53}. Participants selected whether they thought their symptoms would: “get better soon,” “get better slowly,” “never get better,” or “don’t know.” “Never get better” was a rarely endorsed response (n = 1), so this data point was excluded from analyses.

**British Columbia Postconcussion Symptom Inventory (BC-PSI).** The BC-PSI is a 16-item self-report questionnaire that measures the frequency and severity of postconcussion symptoms. Item scores are derived from the ratings on frequency and severity scores. The total BC-PSI score is the sum of the item scores (range: 0–52). This scale’s reliability and validity have been well-established\cite{54–56}. In our sample, internal consistency was high at the initial study assessment (Cronbach’s $\alpha = .96$) and at follow-up (Cronbach’s $\alpha = .96$). Similar to our previous studies, patients were classified as meeting International Classification of Diseases, 10th Revision (ICD-10) criteria for mild postconcussional syndrome (Mild PCS) if they reported symptoms as being mild or worse (i.e., item scores $\geq 2$) in at least three symptom categories (i.e., physical symptoms, cognitive symptoms, emotional symptoms, or sleep-related symptoms)\cite{57,58}. Moderate PCS (i.e., item scores $\geq 3$ greater across three symptom categories) was calculated similarly.

**World Health Organization Disability Assessment Schedule 2.0 (WHODAS)-12 item.** The WHODAS is a brief, cross-cultural and disease non-specific standardized disability instrument\cite{59}. It measures disability in six domains and is sensitive to a variety of medical and psychiatric conditions, including TBI\cite{60–64}. We recently reported that this measure has desirable psychometric characteristics in MTBI, with a sample that overlaps with the present study\cite{65}. Patients select how much difficulty they have experienced over the past 30 days (1/”none” to 5/”extreme or cannot do”, score range: 12–60). The structured interview format was administered in this study. In our sample, internal consistency was high (Cronbach’s $\alpha = .91$).

**Lam Employment Absence and Productivity Scale.** The LEAPS is a questionnaire that assesses work difficulties and absenteeism\cite{66}. On item 4, parts a-g, patients report how much they were bothered by problems like low energy, poor concentration, anxiety, and making mistakes while at work over the past two weeks (0/”none of the time, 0%” to 4/”all of the time, 100%”; score range: 0–28). A total score of 6 or higher indicates some degree of work impairment. In our sample, internal consistency was acceptable for this measure (Cronbach’s $\alpha = .78$). As in a prior study\cite{57}, we used the LEAPS to add granularity to RTW outcome classifications.

**Statistical analyses**

Independent samples t-tests were used to evaluate group differences on continuous variables between the workplace and non-workplace MTBI groups. Analyses of covariance (i.e., ANCO- VAs) were used to compare the groups on measures with continuous variables (i.e., age, PCL-5, IEQ, BC-PSI, WHODAS, number of primary care visits) while statistically controlling for other continuous variables (i.e., weeks from injury to assessment) that may influence this relationship. A small number of patients omitted a single item on the BC-PSI (n = 1) and PCL-5 (n = 5). We imputed these missing values by averaging the participant’s responses to the remainder of the items from that scale and rounding the average item value to the nearest whole number. In so doing, a total of 0.07% (6 of 8,304) questionnaire items were imputed.
We used chi-squared tests to compare the groups on categorical variables. All comparisons used a statistical significance level of $p < .05$.

Logistic regression was used to examine whether the prognostic value of previously established and novel candidate risk factors for delayed RTW after MTBI differed for participants with workplace vs. non-workplace MTBI. “Any RTW” (i.e., partial and full RTW) vs No RTW was the dichotomous outcome. Post-concussion symptom reporting\cite{23,51}, co-occurring orthopedic injuries\cite{23,62}, and self-rated prognosis\cite{51,53} have been significant predictors in prior studies and so were included as predictors in our logistic regression analyses. Self-rated prognosis was treated categorically, with “get better soon” serving as the reference group. Traumatic stress (PCL-5) was included as a predictor because of preliminary evidence of its prognostic utility after MTBI\cite{51} and prolonged symptoms\cite{23}. Further, probable below-capacity performance (i.e., MSVT failure) was included as a predictor because lower PVT scores have been predictive of longer wage replacement benefits (a proxy for RTW) following MTBI\cite{67}. In contrast, variables such as sex and age have not contributed to the prediction of RTW in most prior studies and were omitted from our model\cite{23,51}. We included perceived injustice (IEQ) as a novel predictor of RTW because of its association with poor outcomes and disability in other medical populations\cite{27,30,35} and because it may have an especially potent role in work-related injuries. Injury setting (i.e., workplace vs. non-workplace) was not included in the model because it was not related to RTW outcome in preliminary analyses (see Results). However, we were interested in potential interactions between injury setting and our other variables of interest, with the rationale that some variables (e.g., traumatic stress, perceived injustice) may be more salient and impactful for those injured at work. When introducing this interaction term, we also included the number of weeks between injury and the initial study assessment as a predictor in our analyses to control for the possible bias introduced because the workplace and non-workplace groups were not well-matched on the timing of initial study assessment. Predictors were entered into the logistic regression model in two steps. First, all candidate predictors were entered simultaneously (BC-PSI, PCL, IEQ, MSVT failure, co-occurring orthopedic injury, and self-rated prognosis). Second, the number of weeks between injury and the initial assessment and a single interaction term were added. The second step was repeated for each interaction term (workplace vs. non-workplace group x a predictor entered in the first step), one at time.

**Results**

Demographics and injury characteristics are presented in Table 1. Workplace injuries comprised 45.1% of the final sample ($n = 46$). Participants with a workplace MTBI were somewhat younger than those who sustained a non-workplace MTBI, but this difference was not significant [$t(98) = 1.71, p = .09$]. The workplace MTBI group had a greater proportion of men [$X^2(1) = 7.38, p = .007$] and they were less likely to have been educated beyond high school [56.5% vs. 80.4%, $X^2(1) = 6.78, p = .009$]. Occupation differed between workplace and non-workplace MTBI [$X^2(6) = 19.90, p = .003$], as did mechanism of injury [$X^2(5) = 32.71, p < .001$]. Table 1 provides a breakdown of occupational categories and mechanisms of injury by group. There were no differences in rates of loss of consciousness, amnesia, and confusion/disorientation between workplace and non-workplace MTBI ($p < .05$). The two groups also had a similar rate of a co-occurring orthopedic injury [$X^2(1) = 1.95, p = .16$] and pre-injury mental health treatment [$X^2(1) = 1.52, p = .22$].

The workplace MTBI group had a shorter duration between their injury and the initial study assessment compared to the non-workplace MTBI group [$t(99) = 2.92, p = .004$, Cohen’s $d = -0.60$]. That is, they present for outpatient specialty MTBI care sooner. Time since injury
Table 1. Demographic, injury, and initial assessment characteristics.

|                          | Full Sample (n = 102) | Work Injury (n = 46) | Non-work Injury (n = 56) |
|--------------------------|-----------------------|----------------------|--------------------------|
| **Demographics**         |                       |                      |                          |
| Age, M (SD)              | 41.2 (11.7)           | 39.0 (11.8)          | 43.0 (11.4)              |
| Sex, n (% female)        | 55 (53.9%)            | 18 (39.1%)           | 37 (66.1%)               |
| Education level, n (%)   |                       |                      |                          |
| Did not complete high school | 8 (7.9%)             | 4 (8.7%)             | 4 (7.1%)                 |
| High School              | 23 (22.6%)            | 16 (34.8%)           | 7 (12.5%)                |
| Some College             | 17 (16.7%)            | 8 (17.4%)            | 9 (16.1%)                |
| Diploma                  | 17 (16.7%)            | 8 (17.4%)            | 9 (16.1%)                |
| Bachelor's Degree        | 27 (26.5%)            | 8 (17.4%)            | 19 (33.9%)               |
| Graduate Degree          | 10 (9.8%)             | 2 (4.3%)             | 8 (14.3%)                |
| **Occupation**           |                       |                      |                          |
| Manual Labor             | 20 (19.6%)            | 13 (28.3%)           | 7 (12.5%)                |
| Skilled craft or trade   | 13 (12.7%)            | 9 (19.6%)            | 4 (7.1%)                 |
| Transport                | 4 (3.9%)              | 1 (2.2%)             | 3 (5.4%)                 |
| Sales and service        | 14 (13.7%)            | 7 (15.2%)            | 7 (12.5%)                |
| Clerical                 | 6 (5.9%)              | 0 (0%)               | 6 (10.7%)                |
| Management or professional| 23 (22.5%)            | 4 (8.7%)             | 19 (33.9%)               |
| Other                    | 22 (21.6%)            | 12 (26.1%)           | 10 (17.9%)               |
| **Pre-injury Mental Health Treatment** | 53 (52.0%) | 27 (58.6%) | 26 (46.4%) |
| **Mechanism of Injury, n (%)** |                       |                      |                          |
| Struck by object         | 30 (29.4%)            | 20 (43.5%)           | 10 (17.9%)               |
| Motor vehicle crash      | 29 (28.4%)            | 3 (6.5%)             | 26 (46.4%)               |
| Fall                     | 28 (27.5%)            | 14 (30.4%)           | 14 (25.0%)               |
| Sport                    | 5 (4.9%)              | 0 (0%)               | 5 (8.9%)                 |
| Assault                  | 5 (4.9%)              | 5 (10.9%)            | 0 (0%)                   |
| Other                    | 5 (4.9%)              | 4 (8.7%)             | 1 (1.8%)                 |
| **Loss of Consciousness, n (%)** |                       |                      |                          |
| Witnessed LOC            | 18 (17.7%)            | 5 (10.9%)            | 13 (23.2%)               |
| Unwitnessed LOC          | 23 (22.5%)            | 11 (23.9%)           | 12 (21.4%)               |
| Unknown                  | 12 (11.8%)            | 5 (10.9%)            | 7 (12.5%)                |
| Denied                   | 49 (48.0%)            | 25 (54.3%)           | 24 (42.9%)               |
| **Post-traumatic amnesia, n (%)** | 67 (65.7%) | 33 (71.7%) | 34 (60.7%) |
| Acute confusion/disorientation, n (%) | 90 (88.2%) | 42 (91.3%) | 48 (85.7%) |
| Co-occurring orthopedic injury, n (%) | 63 (61.8%) | 21 (45.7%) | 38 (67.9%) |
| **Initial Assessment Characteristics** |                       |                      |                          |
| Weeks to initial assessment, M (SD) | 12.05 (6.3) | 10.1 (5.5) | 13.7 (6.4) |
| Primary care visits since injury, M (SD) | 6.4 (4.4) | 5.9 (3.9) | 6.8 (4.7) |
| **Self-Reported Treatment Utilization Since Injury, n (%)** |                       |                      |                          |
| Emergency Department     | 78 (76.4%)            | 32 (68.6%)           | 46 (82.1%)               |
| Specialist (e.g., neurologist) | 39 (38.2%) | 24 (52.2%) | 15 (26.8%) |
| Physiotherapist          | 47 (46.1%)            | 19 (41.3%)           | 28 (50.0%)               |
| Occupational Therapist   | 12 (11.8%)            | 4 (8.7%)             | 8 (14.3%)                |
| Psychological therapy/counselling | 10 (9.8%) | 2 (4.3%) | 8 (14.3%) |
| Massage Therapy          | 31 (30.4%)            | 7 (15.2%)            | 24 (42.2%)               |
| Chiropractic treatments  | 12 (11.8%)            | 3 (13.0%)            | 9 (16.1%)                |
| Acupuncture treatment    | 10 (9.8%)             | 3 (6.5%)             | 7 (12.5%)                |

(Continued)
was therefore used as a covariate in comparisons between groups on non-categorical variables (i.e., ANCOVA). Participants had seen their primary care physician an average of 6.4 times (SD = 4.4, Md = 5, IQR = 5–8) before the initial study assessment; there was no significant difference in the number of post-MTBI primary care visits between the workplace (M = 5.9, Md = 5) and non-workplace (M = 6.8, Md = 6) groups (Mann-Whitney U = 1120.0, p = .19).

Additional self-reported healthcare utilization between the injury and initial study assessment can be seen in Table 1.

As expected, virtually all participants with workplace MTBI were off work and receiving administrative (wage loss) benefits at the time of the initial assessment. That is what would have prompted their referral for specialized MTBI treatment. Participants with non-workplace MTBI were more likely to have already returned to work in some capacity \[X^2(3) = 11.16, p = .011\] by the initial assessment and were more likely to be seeking compensation through different means \[X^2(2) = 31.72, p < .001\], such as personal injury litigation (see Table 1). In the initial assessment, the workplace MTBI group had more symptoms of traumatic stress \[PCL-5, F(1, 98) = 4.04, p = .047, \text{adjusted } d = 0.42\] when covarying for weeks since injury. There were no group differences on perceived injustice \[IEQ, F(1, 98) = 2.89, p = .09\], overall post-concussion symptom severity (BC-PSI total score, \(F(1, 98) = 1.39, p = .24\)), or pain \[BPQ, F(1, 97) = 2.75, p = .10\] when covarying for weeks since injury. There were no differences between workplace and non-workplace MTBI groups on performance validity \[MSVT Failures, \chi^2(1) = 0.43, p = .51\] or recovery expectations \[Self Prognosis; X^2(2) = 2.81, p = .25\].

Of the 102 participants who completed the initial assessment at clinic intake, 15 (14.7%) were lost to follow-up. Participants who were lost to follow-up did not differ from those who were retained with respect to age, sex, education (i.e., secondary vs. not), or race/ethnicity.
(Caucasian vs. non-Caucasian; \( p < .05 \)). A similar proportion of patients were lost to follow-up in the workplace and non-workplace MTBI groups \( [X^2(1) = 0.48, p = .49] \). The workplace and non-workplace MTBI groups did not differ on time between the injury and follow-up assessment \( [t(84) = 0.43, p = .67] \). Similar to the initial assessment, the workplace and non-workplace MTBI groups differed in compensation status at follow-up \( [X^2(3) = 25.71, p < .001] \).

Access to treatment is inherently different for patients inside vs. outside of the Worker’s Compensation system. Participants who sustained a non-workplace MTBI typically received only a group education session (100%), with a minority (<10%) receiving additional services in that clinic (e.g., physiatry consultation). Many of these participants reported accessing additional services in the community. In contrast, participants who sustained a workplace MTBI commonly received a brief neuropsychological assessment (100%), medical examination (85.7%), multi-day interdisciplinary assessment (80.9%), multi-week rehabilitation program (68.6%), gradual RTW transition support (57.1%), and a job site visit (40.0%).

Outcomes obtained from the follow-up telephone assessment are shown in Table 2. At follow-up, there were no differences in RTW status between the workplace and non-workplace MTBI groups \( [X^2(2) = 0.16, p = .92; \text{Cramer’s V} = 0.04] \). Collapsing those with full RTW and partial RTW into a single “any RTW” group did not alter the results. At follow-up, there were

### Table 2. Follow-up characteristics.

| Follow-up Characteristics | Follow-up Sample (n = 87) | Work Injury (n = 38) | Non-work Injury (n = 49) |
|---------------------------|---------------------------|---------------------|--------------------------|
| Lost to follow-up, n (%)  | 15 (14.7%)                | 8 (17.4%)           | 7 (12.5%)                |
| Weeks from Injury to Follow-Up, M (SD) | 31.6 (6.1)               | 31.2 (6.2)          | 31.8 (6.0)               |
| Compensation status at follow-up, n (%) |                       |                     |                          |
| No compensation          | 40 (46.0%)                | 24 (63.2%)          | 16 (32.7%)               |
| Seeking/receiving administrative benefits | 23 (26.4%)               | 14 (34.8%)          | 9 (18.4%)                |
| Litigating                | 33 (26.4%)                | 0 (0%)              | 23 (46.9%)               |
| Claim Settled             | 1 (1.1%)                  | 0 (0%)              | 1 (2.0%)                 |
| Primary Outcome           |                           |                     |                          |
| Return to work status, n (%) |                        |                     |                          |
| Full return to work       | 37 (42.5%)                | 17 (44.7%)          | 20 (40.8%)               |
| Partial return to work    | 16 (18.4%)                | 7 (18.4%)           | 9 (18.4%)                |
| No return to work         | 34 (39.1%)                | 14 (36.8%)          | 20 (40.8%)               |
| Secondary Outcomes        |                           |                     |                          |
| Post-Concussion Symptoms; BC-PSI, M (SD) | 20.1 (13.2)              | 20.2 (13.0)         | 19.9 (13.3)              |
| Brief Pain Questionnaire (BPQ), M (SD) | 4.5 (3.7)                | 4.7 (3.4)           | 4.4 (4.0)                |
| ICD-10 Postconcussional Syndrome, n (%) |                       |                     |                          |
| Based on Mild+ Symptoms   | 73 (83.7%)                | 31 (81.6%)          | 41 (85.4%)               |
| Based on Moderate+ Symptoms | 55 (64.9%)               | 23 (60.5%)          | 32 (66.7%)               |
| WHODAS 2.0 Total Score, M (SD) | 25.8 (9.6)               | 25.2 (8.7)          | 26.3 (10.3)              |
| Return to work status (alternate definition) |                     |                     |                          |
| Full RTW with LEAPS ≤ 5   | 20 (23.0%)                | 9 (23.7%)           | 11 (22.4%)               |
| No RTW/Partial RTW/Full RTW with LEAPS ≥ 6 | 67 (77.0%)              | 29 (76.3%)          | 38 (77.6%)               |

Abbreviations: BC-PSI = British Columbia Postconcussion Symptom Inventory; ICD-10 = International Statistical Classification of Diseases and Related Health Problems, 10th Revision; M = mean; RTW = Return to work; SD = standard deviation; WHODAS = World Health Organization Disability Assessment Schedule, 2.0

https://doi.org/10.1371/journal.pone.0198128.t002
no group differences in post-concussion symptoms (BC-PSI, t(84) = -0.10, p = .92, d = 0.07), functional disability (WHODAS, t(85) = 0.55, p = .59, d = -0.12), or pain (BPQ, t(85) = -0.28, p = .78, d = 0.08) between groups. Similar proportions of both groups were operationalized as having mild ICD-10 postconcussional syndrome \( \chi^2(1) = 0.23, p = .63; V = 0.05 \) and moderate ICD-10 postconcussional syndrome \( \chi^2(1) = 0.35, p = .56; V = 0.06 \). Using a more conservative definition of complete RTW (i.e., full RTW and LEAPS score 0–5[57]) did not reveal group differences. A similar proportion of participants in the workplace and non-workplace MTBI groups fully returned to work with normal productivity \( \chi^2(1) = 0.02, p = .89 \).

As shown in Table 3, greater perceived injustice, greater post-concussion symptoms, and answering “don’t know” when symptoms would resolve (compared to “get better soon”) were significantly related to delayed RTW in unadjusted (single predictor) regression models. The logistic regression with all predictor variables (step 1) was well calibrated [Hosmer and Leme-\( \chi^2(7) = 22.41, p = .002 \]. Prediction accuracy was fair (Nagelkerke \( R^2 = .31 \); area under the receiver operating curve = .78, p<.001). In this model, post-concussion symptoms and traumatic stress symptoms were statistically significant, such that greater post-concussion symptoms and less traumatic symptoms were associated with not working at follow-up. These results did not change in Step 2, when time between injury and initial assessment were entered into the model. Further, none of the ‘injury setting-by-predictor’ interaction terms were statistically significant, indicating that none of the candidate risk factors were differentially related to RTW outcome in the workplace vs. non-workplace groups.

### Discussion

There are important differences between the pre-injury characteristics, mechanisms of injury, health care services, and recovery trajectories between people who sustain an MTBI in sport,
military, and civilian trauma settings\cite{68,69}. Prior studies examining traumatic injuries of all kinds have reported that people who are injured in workplace accidents are at elevated risk for poor outcomes\cite{7,70}. The primary aim of the present study was to compare patients with workplace vs. non-workplace MTBI. We studied patients who were referred to specialty care because of atypical recovery following MTBI. Almost all participants met ICD-10 symptom criteria for postconcussional syndrome during the study period, and their symptom reporting was likely influenced by factors separate from neurotrauma (such as traumatic stress, persistent bodily pain, and exaggeration). When interpreting the results of this study, it is important to appreciate that the sample was specialty clinic-referred, and generally slow-to-recover, highly symptomatic, with disproportionately high rates of risk factors for poor outcome. We hypothesized that patients injured at work would be a distinct subgroup, with more adverse risk profiles and lower rates of RTW compared to patients who were injured in other settings. We expected that our findings would support a stratification that may help explain the heterogeneity of MTBI outcomes. Overall, our study did not demonstrate important differences between workplace and non-workplace related MTBIs in these specialty clinic samples.

We found similarities and differences between patients with persistent symptoms following workplace vs. non-workplace MTBI. The two groups similarly accessed primary care during the acute post-injury period, but patients with workplace MTBI presented for outpatient specialty care a few weeks faster, on average. This difference is not surprising because those with a Worker’s Compensation claim are assigned a case manager whose role it is to monitor the worker’s recovery and to initiate referrals for treatment. For people who sustain an MTBI in other settings, navigating health care services are generally left to the patient themselves and/or their primary care provider. Consistent with the broader literature on musculoskeletal injuries\cite{21–24}, patients with workplace MTBI were more likely to be male blue-collar workers without a Bachelor’s or graduate degree. Falls were a common mechanism of injury in both groups, but patients with workplace injuries most frequently sustained their MTBI by being struck with an object, whereas motor vehicle accidents were the most frequent cause of non-workplace MTBI.

At clinic intake (2–3 months post injury), there were no significant group differences in post-concussion symptoms, perceived injustice, or expectations for recovery. The only difference was that workplace MTBI was associated with greater PTSD symptoms. This could, in part, be related to the differences in mechanisms of injuries (e.g., more assaults, fewer sport injuries). Despite differences in compensation access (patients with Worker’s Compensation Claims receive administrative benefits but cannot sue whereas patients with non-workplace injuries may not have access to administrative benefits but often can seek compensation through personal injury litigation), the rate of suspected exaggeration on neuropsychological testing (performance validity test failure) was similar and fairly high in both groups (20–25%).

The workplace and non-workplace MTBI groups were indistinguishable at follow-up, 6–7 months post injury. A very similar number had returned to work in a partial (18–19%) or full (37–41%) capacity. They also reported a similar burden of residual post-concussion symptoms (on the BC-PSI), functional disability (on the WHODAS), and pain (on the BPQ). An absence of differences in post-acute outcome is in keeping with the finding that workplace MTBI was associated with both favorable (male sex) and unfavorable (low education and job decision-making latitude) prognostic factors, and similar psychosocial profiles to participants with non-workplace MTBI at clinic intake, with the exception of more PTSD symptoms. However, the absence of differences in post-acute outcome might be surprising when considering that patients with workplace MTBI received more comprehensive and coordinated rehabilitation services. It is difficult to draw conclusions about why these two workplace and non-workplace MTBI groups ended up looking similar at follow-up. It may be that the workplace MTBI
group was at greater risk of poor outcome due to unmeasured variables, and the timely and extensive rehabilitation they received offset that increased risk. It is also possible that both groups were on a similarly poor recovery trajectory, and the health services they received did not substantially influence their trajectories. We entertained that the workplace and non-workplace MTBI groups may have achieved similar outcomes via different pathways, and so also sought to examine whether certain risk factors for delayed RTW would be stronger in the workplace MTBI group. In single predictor models, perceived injustice, post-concussion symptoms, and having uncertain (vs. optimistic) recovery expectations at the time of clinic intake were associated with lower likelihood of returning to work 4–5 months later (i.e., by 6–7 months following injury). After adjusting for all variables in the model, only greater post-concussion symptoms were associated with a lower likelihood of RTW at follow-up. This is consistent with previous studies[23,51] demonstrating that symptom burden is predictive of a protracted recovery. Additionally, the multivariate model showed an association between lower traumatic stress symptoms and worse outcome. We suspect that this finding is an artefact of statistical suppression. Traumatic stress was not associated with RTW in unadjusted (single predictor) modeling but was highly correlated with post-concussion symptoms (r = .60). The collinearity of these measures likely enhanced the relationship between post-concussion symptoms and the outcomes (i.e., OR 1.06 to 1.10) and suppressed the relationship between traumatic stress and the outcome (i.e., 1.01 to 0.93). Contrary to our hypotheses that certain risk factors would be differentially associated with the workplace MTBI group, there were no statistically significant interactions effects.

This study has several noteworthy limitations. First, the workplace and non-workplace MTBI groups were not matched on the timing of their first assessment. This was an observational study and our two groups had inherently different access to healthcare. We employed a covariate adjustment for time since injury wherever possible. Second, we had very limited information on the screened participants who did not enroll in this study, precluding the analyses necessary to understand the presence and impact of selection bias. Third, as with all longitudinal studies, there was attrition. The rates of attrition were similar in both MTBI groups, and those who were lost to follow-up had similar demographics compared to those who were retrained. It seems unlikely that attrition biased the group comparisons of primary interest, workplace vs. non-workplace. Fourth, injury characteristics were assessed via self-report during a structured interview. Medical records were not available to review. Although self-reported data has limitations[71,72], the primary hypotheses regarding differences between the workplace and non-workplace MTBI groups should not be affected by these limitations. Fifth, the workplace and non-workplace MTBI groups differed on their treatment utilization following clinic intake. This imbalance is inherent to the health care system. Sixth, it is possible that we did not find group differences in outcomes because of sample size and statistical power limitations. However, the small magnitudes of the observed effect sizes suggest that large differences between work and non-work MTBIs are unlikely. Lastly, the follow-up period was not long enough to observe the outcome of interest (RTW) in large proportion of the sample, which precluded more powerful (time-to-event) statistical modeling techniques.

In summary, despite systemic differences in compensation and health care access, the workplace and non-workplace MTBI groups were similar at clinic intake and indistinguishable at follow-up, 6–7 months following injury. The workplace MTBI group had different demographic profiles (i.e., more men, lower education levels, fewer managerial/professional jobs) and greater traumatic stress symptoms at the initial assessment, but these differences did not translate into measurable divergence on any outcome measure. There was no evidence for risk factors for delayed RTW being more or less relevant to patients with workplace MTBI vs non-workplace MTBI. At the follow-up assessment 6–7 months after MTBI, a minority of
individuals had achieved their pre-injury work productivity levels, and the large majority continued to meet symptom criteria for at least mild ICD-10 postconcussional syndrome. It is important to interpret these findings in the context of our study design. Participants in both groups were clinic-referred, slow-to-recover, highly symptomatic, and had disproportionately high rates of risk factors for poor outcome. They were not representative of all people who sustain an MTBI. However, the present findings may generalize to other outpatient clinic settings where patients with MTBI are commonly seen. This study highlights the need for intervention research to improve functional outcomes in patients with MTBI who present for outpatient care. An improved characterization of risk factors could inform a personalized medicine approach, whereby injured workers are matched to therapies designed to target the source of their heightened risk.

Supporting information
S1 Dataset. Excel spreadsheet containing the study dataset. (XLSX)

Acknowledgments
The authors wish to thank research assistants Mary Ellen Johnson and Sabrina Khan as well as the clinical staff at our recruitment sites, including Kelsey Davies, Jennifer Loffree, Grace Boutilier, and Trish Mahoney (GF Strong Rehab Centre), Deanna Yells, Heather MacNeil, Ali Sacks, Rod Macdonald and Andrew Fairbairn (Fraser Health Concussion Clinic), Denise Silva and Lesley Norris (Back in Motion), and Karilyn Lao, Wayne Tang, and Cyrus Huang (LifeMark).

Author Contributions
Conceptualization: Douglas P. Terry, Grant L. Iverson, William Panenka, Angela Colantonio, Noah D. Silverberg.
Data curation: Noah D. Silverberg.
Formal analysis: Douglas P. Terry.
Funding acquisition: William Panenka, Noah D. Silverberg.
Methodology: Noah D. Silverberg.
Project administration: William Panenka, Noah D. Silverberg.
Resources: Noah D. Silverberg.
Supervision: Grant L. Iverson.
Validation: Angela Colantonio.
Writing – original draft: Douglas P. Terry, Noah D. Silverberg.
Writing – review & editing: Douglas P. Terry, Grant L. Iverson, William Panenka, Angela Colantonio, Noah D. Silverberg.

References
1. Kristman VL, Côté P, Hogg-johnson S, Cassidy JD, Eerd V, Vidmar M, et al. The Burden of Work Disability Associated with Mild Traumatic Brain Injury in Ontario Compensated Workers: A Prospective Cohort Study. Open Occup Heal Saf J. 2010; 2: 1–8.
2. Kristman VL, Côté P, Van Eer D, Vidmar M, Rezai M, Hogg-Johnson S, et al. Prevalence of lost-time claims for mild traumatic brain injury in the working population: improving estimates using workers compensation databases. Brain Inj. 2008; 22: 51–9. https://doi.org/10.1080/02699050701849991 PMID: 18183509

3. Colantonio A, Mroczek D, Patel J, Lewko J, Fergenbaum J, Brison R. Examining occupational traumatic brain injury in Ontario. Can J Public Health. 2010; S58–62. Available: http://www.ncbi.nlm.nih.gov/pubmed/20629449 PMID: 20629449

4. Kim H, Colantonio A, Chipman M. Traumatic brain injury occurring at work. NeuroRehabilitation. 2006; 21: 269–78. PMID: 17361044

5. Chang VH, Lombard LA, Greher MR. Mild Traumatic Brain Injury in the Occupational Setting. PM&R. 2011; 3: S387–S395. https://doi.org/10.1016/j.pmrj.2011.08.007 PMID: 22035681

6. Colantonio A, Comper P. Post-injury symptoms after work related traumatic brain injury in Canadian population. Work. 2012; 43: 195–201. https://doi.org/10.3233/WOR-2012-1377 PMID: 22927617

7. Lilley R, Davie G, Langley J, Ameratunga S, Derrett S. Do outcomes differ between work and non-work-related injury in a universal injury compensation system? Findings from the New Zealand Prospective Outcomes of Injury Study. BMC Public Health. BMC Public Health; 2013; 13: 995. https://doi.org/10.1186/1471-2458-13-995 PMID: 24148609

8. Mason S, Wardroppe J, Turpin G, Rowlands A. Outcomes after injury: a comparison of workplace and nonworkplace injury. J Trauma. 2002; 53: 98–103. https://doi.org/10.1097/00005373-200207000-00019 PMID: 12131397

9. Paniak C, Toller-lobe G, Melnyk A, Nagy J. Prediction of Vocational Status Three to Four Months After Treated Mild Traumatic Brain Injury. J Musculoskelet Pain. 2000; 8: 193–200. https://doi.org/10.1300/J094v08n01_16

10. Scuderi GJ, Sherman AL, Brusovanik G V, Pahl M a, Vaccaro AR. Symptomatic cervical disc herniation following a motor vehicle collision: return to work comparative study of workers’ compensation versus personal injury insurance status. Spine J. 2005; 5: 639–44; discussion 644. https://doi.org/10.1016/j.spinee.2005.04.007 PMID: 16291103

11. Iverson GL, Lange RT, Brooks BL, Rennison VLA. “Good old days” bias following mild traumatic brain injury. Clin Neuropsychol. 2010; 24: 17–37. https://doi.org/10.1080/13854040903190797 PMID: 19830628

12. Mollayeva T, Shapiro CM, Mollayeva S, Cassidy JD, Colantonio A. Modeling community integration in workers with delayed recovery from mild traumatic brain injury. BMC Neurol. BMC Neurology; 2015; 15: 194. https://doi.org/10.1186/s12883-015-0432-z PMID: 26452471

13. Bazarian JJ, Mcclung J, Shah MN, Ting Cheng Y, Flesher W, Kraus J. Mild traumatic brain injury in the United States, 1998–2000. Brain Inj. 2005; 19: 85–91. https://doi.org/10.1080/02699050541001720158 PMID: 15841752

14. Martin CW. Mild Traumatic Brain Injury: Review of the literature and a look at the WCB of BC data. Worker’s Compensation Board of British Columbia Compensation and Rehabilitation Services Division. 2003.

15. Chang VC, Guerriero EN, Colantonio A. Epidemiology of Work-related Traumatic Brain Injury: A Systematic Review. Am J Ind Med. 2015; 58: 353–377. https://doi.org/10.1002/ajim.22418 PMID: 25731875

16. Silverberg ND, Gardner A, Brubacher JR, Panenka W, Li JJ, Iverson GL. Systematic review of multivariable prognostic models for mild traumatic brain injury. Under Rev. 2014;

17. Bazarian JJ, Blyth B, Mookerjee S, He H, McDermott MP. Sex differences in outcome after mild traumatic brain injury. J Neurotrauma. 2010; 27: 527–539. https://doi.org/10.1089/neu.2009.0168 PMID: 19938945

18. King NS. A systematic review of age and gender factors in prolonged post-concussion symptoms after mild head injury. Brain Inj. 2014; 28: 1639–45. https://doi.org/10.3109/02699052.2014.954271 PMID: 25265040

19. Guerriero EN, Smith PM, Stergiou-Kita M, Colantonio A. Rehabilitation utilization following a work-related traumatic brain injury: A sex-based examination of workers’ compensation claims in Victoria, Australia. PLoS One. 2016; 11. https://doi.org/10.1371/journal.pone.0151462 PMID: 26982491

20. Stergiou-Kita M, Mansfield E, Sokolof S, Colantonio A. Gender Influences on Return to Work After Mild Traumatic Brain Injury. Arch Phys Med Rehabil. 2016; 97: S40–5. https://doi.org/10.1016/j.apmr.2015.04.008 PMID: 25921979

21. Friedland JF, Dawson DR. Function after motor vehicle accidents: a prospective study of mild head injury and posttraumatic stress. J Nerv Ment Dis. 2001; 189: 426–434. PMID: 11504319
22. Ruffolo CF, Friedland JF, Dawson DR, Colantiono a, Lindsay PH. Mild traumatic brain injury from motor vehicle accidents: factors associated with return to work. Arch Phys Med Rehabil. 1999; 80: 392–398. PMID: 10206600

23. Stulenmeijer M, van der Werf S, Borm GF, Ves PE. Early prediction of favourable recovery 6 months after mild traumatic brain injury. J Neurol Neurosurg Psychiatry. 2008; 79: 936–942. https://doi.org/10.1136/jnnp.2007.131250 PMID: 17951281

24. Xiong C, Martin T, Sravanapudi A, Colantiono A, Mollayeva T. Factors associated with return to work in men and women with work-related traumatic brain injury. Disabil Health J. Elsevier Inc; 2016; 9: 439–448. https://doi.org/10.1016/j.dhjo.2015.12.002 PMID: 26817582

25. Turner J a, Franklin G, Fulton-Kehoe D, Sheppard L, Wickizer TM, Wu R, et al. Worker recovery expectations and fear-avoidance predict work disability in a population-based workers’ compensation back pain sample. Spine (Phila Pa 1976). 2006; 31: 682–9. https://doi.org/10.1097/01.brs.0000202762.88787.af PMID: 16540874

26. Schultz IZ, Crook J, Meloche GR, Berkowitz J, Zuberbier OA, et al. Psychosocial factors predictive of occupational low back disability: Towards development of a return-to-work model. Pain. 2004; 107: 77–85. https://doi.org/10.1016/j.pain.2003.09.019 PMID: 14715392

27. Sullivan MJL, Adams Æh, Horan Æs, Maher Æd, Boland D, Gross Ær. The Role of Perceived Injustice in the Experience of Chronic Pain and Disability: Scale Development and Validation. 2008; https://doi.org/10.1007/s10926-008-9140-5 PMID: 18536983

28. Sullivan MJL, Adams Æh, Horan Æs, Maher Æd, Boland D, Gross Ær. The Role of Perceived Injustice in the Experience of Chronic Pain and Disability: Scale Development and Validation. 2008; https://doi.org/10.1007/s10926-008-9140-5 PMID: 18536983

29. Sullivan MJL, Adams H, Martel M-O, Scott W, Wideman T. Catastrophizing and perceived injustice: risk factors for the transition from chronicity after whiplash injury. Spine (Phila Pa 1976); 2011; 36: S244–9. https://doi.org/10.1097/BRS.0b013e31823837ed PMID: 22020619

30. Sullivan MJL, Thibaut P, Simmonds MJ, Milliot MO, Cantin AP, Veily AM. Pain, perceived injustice and the persistence of post-traumatic stress symptoms during the course of rehabilitation for whiplash injuries. Pain. 2009; 145: 325–331. https://doi.org/10.1016/j.pain.2009.06.031 PMID: 19643543

31. Mansfield E, Stergiou-Kita M, Cassidy JD, Bayley M, Mantis S, Kristman V, et al. Return-to-work challenges following a work-related mild TBI: The injured worker perspective. Brain Inj. 2015; 29: 1362–1369. https://doi.org/10.3109/02699052.2015.1053524 PMID: 26287754

32. Carlson KF, Kehle SM, Meis L a, Greer N, Macdonald R, Rutks I, et al. Prevalence, assessment, and treatment of mild traumatic brain injury and posttraumatic stress disorder: a systematic review of the evidence. J Head Trauma Rehabil. 2011; 26: 103–115. https://doi.org/10.1097/HTR.0b013e3181e50ef1 PMID: 20631631

33. MacDonald H a, Colotia V, Flamer S, Karlinsky H. Posttraumatic stress disorder (PTSD) in the workplace: a descriptive study of workers experiencing PTSD resulting from work injury. J Occup Rehabil. 2003; 13: 63–77. PMID: 12708101

34. Holm L, David Cassidy J, Carroll L, Borg JJ, Neurotrauma Task Force on Mild Traumatic Brain Injury of the WHO Collaborating Centre. Summary of the WHO collaborating centre for neurotrauma task force on mild traumatic brain injury. J Rehabil Med. 2005; 37: 137–141. https://doi.org/10.1080/16501975010027321 PMID: 16040469

35. Scott W, Trost Z, Milliot M, Sullivan MJL. Further validation of a measure of injury-related injustice perceptions to identify risk for occupational disability: a prospective study of individuals with whiplash injury. J Occup Rehabil. 2013; 23: 557–65. https://doi.org/10.1007/s10926-013-9417-1 PMID: 23358220

36. Kennedy L, Dunstan DA. Confirmatory Factor Analysis of the Injustice Experience Questionnaire in an Australian Compensable Population. Journal of Occupational Rehabilitation. 2013; 1–8.

37. Blevins CA, Weathers FW, Davis MT, Witte TK, Domino JL. The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. J Trauma Stress. 2015; 28: 489–498. https://doi.org/10.1002/jts.22059 PMID: 26606250

38. Wortmann JH, Jordan AH, Weathers FW, Resick PA, Donandville KA, Hall-Clark B, et al. Psychometric analysis of the PTSD Checklist-5 (PCL-5) among treatment-seeking military service members. Psychol Assess. 2016; 28: 1392–1403. https://doi.org/10.1037/pas0000260 PMID: 26751087

39. Binder LM, Rohling ML. Money matters: A meta-analytic review of the effects of financial incentives on recovery after closed-head injury. Am J Psychiatry. 1996; 153: 7–10.

40. Carroll LJ, Cassidy JD, Peloso PM, Borg J, von Holst H, Holm L, et al. Prognosis for mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med. 2004; 84–105. Available: http://www.ncbi.nlm.nih.gov/pubmed/15083873
41. Green P, Rohling ML, Lees-Haley PR, Allen LM. Effort has a greater effect on test scores than severe brain injury in compensation claimants. Brain Inj, 2001; 15: 1045–60. https://doi.org/10.1080/02699050110088254 PMID: 11712951

42. Bigler ED. Effort, symptom validity testing, performance validity testing and traumatic brain injury. Brain Inj, 2014; 28: 1623–1638. https://doi.org/10.3109/02699052.2014.947627 PMID: 25215453

43. Webb JW, Batchelor J, Meares S, Taylor A, Marsh N V. Effort test failure: toward a predictive model. Clin Neuropsychol, 2012; 26: 1377–96. https://doi.org/10.1080/13854046.2012.728248 PMID: 23061431

44. Carone DA. Children with moderate/severe brain damage/dysfunction outperform adults with mild-to-no brain damage on the Medical Symptom Validity Test. Brain Inj, 2008; 22: 960–971. https://doi.org/10.1080/02699050802491297 PMID: 19005888

45. Whitney KA, Shepard PH, Williams AL, Davis JJ, Adams KM. The Medical Symptom Validity Test in the evaluation of Operation Iraqi Freedom/Operation Enduring Freedom soldiers: A preliminary study. Arch Clin Neuropsychol, 2009; 24: 145–152. https://doi.org/10.1093/arclin/acp020 PMID: 19395348

46. Whitney KA, Shepard PH, Williams AL, Davis JJ, Adams KM. The Medical Symptom Validity Test in the evaluation of Operation Iraqi Freedom/Operation Enduring Freedom soldiers: A preliminary study. Arch Clin Neuropsychol, 2009; 24: 145–152. https://doi.org/10.1093/arclin/acp020 PMID: 19395348

47. Kirkwood MW, Kirk JW. The base rate of suboptimal effort in a pediatric mild TBI sample: performance measures in a nonclinical sample. J Head Trauma Rehabil. 2011; 26: 170–176. https://doi.org/10.1097/HTR.0b013e31821e47f95 PMID: 20447932

48. Iverson GL, Lange RT. Examination of “post-concussion-like” symptoms in a healthy sample. Appl Neuropsychol. 2003; 10: 137–144. https://doi.org/10.1207/S15324826AN1003_02 PMID: 12890639

49. Silverberg ND, Panenka WJ, Iverson GL. Work Productivity Loss After Mild Traumatic Brain Injury. Arch Phys Med Rehabil. 2017; https://doi.org/10.1016/j.apmr.2017.07.006 PMID: 28760573

50. Iverson G. Misdiagnosis of the persistent postconcussion syndrome in patients with depression. Arch Clin Neuropsychol, 2006; 21: 303–310. https://doi.org/10.1016/j.acn.2005.12.008 PMID: 16797916

51. Badley E, Hoek H, Prince M, Epping-jordan J, Kessler R, Saxena S. WORLD HEALTH ORGANIZATION DISABILITY ASSESSMENT SCHEDULE. 2000.

52. Pösl M, Cieza A, Stucki G. Psychometric properties of the WHODAS II in rehabilitation patients. Qual Life Res, 2007; 16: 1521–31. https://doi.org/10.1007/s11136-007-9259-4 PMID: 17828578

53. Ustün TB, Chatterji S, Kostanjsek N, Rehm J, Kennedy C, Epping-Jordan J, et al. Developing the World Health Organization Disability Assessment Schedule 2.0. Bull World Health Organ. 2010; 88: 815–23. https://doi.org/10.2471/BLT.09.067231 PMID: 21076562

54. Woljas M, Iverson GL, Lange RT, Lillmaätinen S, Hartikainen KM, Dastidar P, et al. Return to Work Following Mild Traumatic Brain Injury. 2014; 29: 443–450. https://doi.org/10.1097/HTR.0000000000000020 PMID: 24263178
63. Svestkova O, Angerova Y, Sladkova P, Bickenbach JE, Raggi A. Functioning and disability in traumatic brain injury. Disabil Rehabil. 2010;32 Suppl 1: S68–77. https://doi.org/10.3109/09638288.2010.511690 PMID: 20929314

64. Derrett S, Davie G, Ameratunga S, Wyeth E, Colhoun S, Wilson S, et al. Prospective Outcomes of Injury Study: recruitment, and participant characteristics, health and disability status. Inj Prev. 2011;17:415–8. https://doi.org/10.1136/injuryprev-2011-040044 PMID: 21724742

65. Snell DL, Iverson GL, Panenka WJ, Silverberg ND. Preliminary validation of the WHODAS 2.0 for mild traumatic brain injury. J Neurotrauma. 2017;In Press.

66. Lam RW, Michalak EE, Yatham LN. A new clinical rating scale for work absence and productivity: validation in patients with major depressive disorder. BMC Psychiatry. 2009;9:78. https://doi.org/10.1186/1471-244X-9-78 PMID: 19958540

67. Colangelo A, Abada A, Haws C, Park J, Niemeläinen R, Gross DP. Word Memory Test Predicts Recovery in Claimants With Work-Related Head Injury. Arch Phys Med Rehabil. 2016;97:714–719. https://doi.org/10.1016/j.apmr.2015.12.019 PMID: 26772529

68. Reid MW, Velez CS. Discriminating military and civilian traumatic brain injuries. Molecular and Cellular Neuroscience. 2015. pp. 123–128. https://doi.org/10.1016/j.mcn.2015.03.014 PMID: 25827093

69. Rabinowitz AR, Li X, Levin HS. Sport and Nonsport Etiologies of Mild Traumatic Brain Injury: Similarities and Differences. Annu Rev Psychol. 2014;65:301–331. https://doi.org/10.1146/annurev-psych-010213-115103 PMID: 24215134

70. Gross N, Young T, Ramirez M, Leinenkugel K, Peek-Asa C. Characteristics of Work- and Non-work-Related Farm Injuries. J Rural Health. 2015;31:401–9. https://doi.org/10.1111/jrh.12121 PMID: 26032601

71. Bush SS, Iverson GL. Neuropsychological assessment of work-related injuries [Internet]. Guilford Press; 2012. https://www.guilford.com/books/Neuropsychological-Assessment-of-Work-Related-Injuries/Bush-Iverson/9781462502271

72. Sbordone RJ, Ruff RM. Re-examination of the Controversial Coexistence of Traumatic Brain Injury and Posttraumatic Stress Disorder: Misdiagnosis and Self-Report Measures. Psychol Inj Law. Springer; 2010;3:63–76. https://doi.org/10.1007/s12207-010-9066-z PMID: 20927197