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Mild traumatic brain injury caused by workplace violence in a US workers' compensation system

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ABSTRACT

Objectives Approximately 81% of traumatic brain injury cases are considered to be mild (mTBI), but few studies have reviewed mTBI caused by workplace violence (WPV). This study aimed to (1) determine the incidence of mTBI secondary to WPV in a statewide workers' compensation system using International Classification of Disease codes and (2) analyse and compare factors associated with return-to-work outcomes between WPV mTBI cases versus other mechanisms.

Methods Using a retrospective cohort of claims data from the California Workers' Compensation Information System during 2015–2019, cases with a return-to-work date were classified as WPV if the injury description contained keywords such as assault, gunpoint, harassed, intimidated, punch, threat, robbery, violent or verbal abuse.

Results Of the 14 089 mTBI claims analysed in this study, 11.2% were caused by WPV. When comparing WPV to non-WPV claims, the variables with statistically significant ($p \leq 0.001$) differences were age, income, industry and job class. There were no significant differences between groups for leave duration. In a linear mixed model, the variable of interest (WPV) was not associated with recovery duration after adjusting for other factors.

Conclusion To our knowledge, this is the first study to examine WPV mTBI claims in the USA. The findings suggest that the public administration, education and healthcare and social services industries are at higher risk for WPV mTBI. WPV and job class were the only modifiable factors in the model and therefore should be the focus of additional research.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Both mild traumatic brain injury (mTBI) and workplace violence (WPV) are significant concerns for worker safety, but there are no current estimates of WPV mTBI in the USA.

WHAT THIS STUDY ADDS

⇒ This is the first study examining workers with mTBI caused by WPV in the USA. Findings suggest that education and public administration industries, along with healthcare and social services, are at higher risk for WPV mTBI. Additionally, there was no difference in the duration of time away from work after an mTBI between the WPV and non-WPV groups.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This research identified which employees and industries are at higher risk for WPV mTBI, which may be helpful for those overseeing worker safety. It also adds to the body of research exploring if WPV-caused injuries are different than injuries caused by other mechanisms.

INTRODUCTION

Each year in the USA, two to three million people sustain a traumatic brain injury (TBI).[1] Approximately 81% of TBI cases are considered to be mild TBI (mTBI) and between 20% and 50% of patients with mTBI experience limitations, such as fatigue, headaches, an inability to maintain previous workloads and behavioural issues 3–12 months after injury.[2–4] An estimated 18% of TBI cases are work related and most commonly occur in the education, healthcare, construction, manufacturing and transportation industries, with injury mechanisms including falls, being struck by an object, vehicle crashes and assaults.[5] Workers with additional psychological injuries due to violence may have longer leave durations and could require specialised trauma-focused care.[6 7] Assaults in the workplace leading to mTBI predicted time away from work in an Australian cohort of injured workers.[8]

Workplace violence (WPV) is defined as incidents where employees are abused, threatened, harassed or assaulted in circumstances related to their work and has been associated with both poor mental health outcomes and workplace absence in certain industries.[9–11] Acts of violence are the fifth leading cause of non-fatal occupational injuries and third leading cause of occupational fatalities in the USA.[12 13] Few studies have reviewed the impact of mTBI caused by WPV with only two studies, from Canada and Australia, finding 6%–9% of cases caused by WPV.[8 14]

After an injury or illness, returning to work or activity is a major milestone in recovery that supports both mental and physical health.[15] Support from family, friends, treating clinicians and employers are important factors in the perceived ability to return to work (RTW) for patients with TBI.[16] Among patients with TBI, pre-injury job category and education level can influence RTW outcomes; notably, those in professional and managerial positions return to their jobs more often and faster than those in manual labour jobs.[17 18] The duration of time away from work, the cost of care and the

volume of injuries could be motivating factors for employers to prioritise injury prevention.[19] In the USA in 2022, an estimated 108 million workdays were lost due to work-related injuries and the total cost, including wage and productivity lost, medical care, administrative expenses and employers' uninsured cost was US$167 billion.[20] The duration a person is out of work after an injury can be an important benchmark to measure successful care and RTW programmes.

Given the burden of work-related mTBI and impact of WPV as a mechanism of mTBI, this study aimed to determine the incidence of mTBI secondary to WPV in a statewide workers' compensation system. It also analyses and compares factors associated with RTW outcomes between mTBI cases caused by WPV versus other work-related mechanisms.

METHODS

This study used a retrospective cohort design with 5 years of claims data (2015–2019) from the California Workers' Compensation Information System (WCIS) for those aged 18–65 years at the time of injury. This dataset includes information about the injury or illness, demographics of the worker, information about the employer and medical care related to the claim. Injury dates after 2019 were excluded because of the COVID-19 pandemic's impact on in-person work, access to care and WPV.[21 22] Claims were included in the analysis if (1) the first date of injury occurred between 2015 and 2019 and (2) the claim was approved by the California workers' compensation system, even if after 2019. Data were obtained through 2022. In California, if a workplace injury results in lost work time beyond the date of the incident or medical treatment beyond first aid, employers must report it to the state-run workers compensation programme.[23] This data is collected by the State of California Department of Industrial Relations and is available on request for research. The data includes demographics about the injured worker, employer location and basic job information including job class. Job class, defined by the US Department of Labor, describes the physical demand needed at work: sedentary (lift up to 10 pounds (lbs) occasionally), light work (lift up to 20 lbs occasionally, 10 lbs frequently), medium work (lift up to 50 lbs occasionally, 25 lbs frequently), heavy work (lift up to 100 lbs occasionally, 50 lbs frequently) or very heavy work (lift excess of 100 lbs occasionally, 50 lbs frequently).

Data categorisation

The International Classification of Disease (ICD) 9 and 10 codes were used to determine if a claim contained a TBI diagnosis. Cases were then classified as mild, moderate/severe or unspecified based on the ICD-10 code definitions of loss of consciousness (LOC): mild is no LOC or less than 30 min of LOC, moderate/severe is 30 or more minutes LOC and unspecified does not have a described LOC.[24] ICD-9 claims were considered mild if they had no LOC or a brief (less than 1 hour) of LOC. This definition of mTBI is consistent with the WHO taskforce and other research.[25 26] This consisted of 35 ICD-9 codes and 120 ICD-10 codes which indicate mTBI within the following categories: concussion (S06.0), traumatic cerebral oedema (S06.1), diffuse TBI (S06.2), focal TBI (S06.3), epidural haemorrhage (S06.4), traumatic subdural haemorrhage (S06.5), traumatic subarachnoid haemorrhage (S06.6), other specified intracranial injuries (S06.7), unspecified intracranial injury (S06.9), concussion (850), cerebral laceration and contusion (851), subarachnoid subdural and extradural haemorrhage following injury (852), other unspecified intracranial haemorrhage following injury (853) and intracranial injury of other and unspecified nature (854). If a claim had multiple severity ICD codes, the most severe was used. Any non-TBI diagnostic code(s) within the claim was classified as a co-occurring condition and then grouped as 1–4 co-occurring condition(s) or 5 or more co-occurring conditions to classify claims likely impacted by non-TBI health conditions.

TBI coding requires additional consideration because ICD-10-CM codes indicate if care is a first-time visit, ongoing care or a sequela—a complication arising as a direct result of the condition. This study excluded claims that only contained sequela code(s) as well as any cases that resulted in a fatality to focus on acute mTBI care. A recovery duration was considered to be the calendar days from the date of injury recorded on the claim until the date of release to work. A release to work, which could include 0 days if no work was missed, indicates that the person was back at work in their same job but could be receiving modified job duties, like alternative work tasks, if they were unable to do their regular job. Claims that were missing an end date or a release to work date were dropped from the analysis.

The Occupational Safety and Health Administration (OSHA) definition of occupational violence, which is "any act or threat of physical violence, harassment, intimidation, or other threatening disruptive behavior that occurs at the work site," was used for this study and is consistent with definitions by the WHO and the Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health.[10 27] Cases were classified as WPV if the available free-text injury description summary, which is a short description of how the person was injured, described a situation caused by WPV. These were coded based on keywords, including past tense, plurals and misspellings of: assault, abuse, agitated, altercation, ambushed, angry, armed, assailant, attack, battered, beaten, bullet, choked, confrontation, defending, dispute, exposing, fighting, fist, gunpoint, harassed, headlock, intimidated, kicked, knife, mugged, murder, profanity, punch, pushed, raped, restraining, robbery, sexually, shot, spat, stabbed, stalked, threat, violent, verbal abuse or verbal aggression a strategy used in similar research.[7] Claims with the keywords victim or struck were each manually reviewed to determine inclusion and claims containing the keywords witnessing or panic attacks were excluded. After finalisation of these categories, the claims were again manually reviewed in detail. Witnessing a violent event, including death, is not part of the OSHA definition of WPV and therefore was categorised as non-WPV.

Statistical analyses

χ^2 or Wilcoxon test was used to compare categorical or continuous variables between the WPV and non-WPV groups with a p value of 0.01 set *a priori* because of the large size of the initial dataset. Then, a linear mixed model with industry as the random effect was used to adjust the recovery duration by demographic. The industry variable used the 20 major categories from the North American Industry Classification System (NAICS). If demographic data was missing, the claim was not included in the model. Analyses were conducted in R software V.4.2.0 (R Core Team, 2020).

RESULTS

This study found 27 307 mTBI claims of which 14 089 had a release to work date. The majority of cases, according to ICD classifications, were mild concussions (83.0%), mild focal TBI (7.7%) or mild diffuse TBI (2.8%). The overall cohort had slightly more men (57.1%), with a median age of 43 years, a median income of US$38 500 and residence in an urban setting

Table 1 Demographic and claim characteristics of mild traumatic brain injury cohort and outcome variables

		WPV (n=1577)	%	Non-WPV (n=12 512)	%	P value
Sex	Males	901	57.1	7139	57.1	0.538
	Females	671	42.5	5307	42.4	
	Missing	5	0.0	66	0.5	
Age	18–30 years	407	25.8	2932	23.4	<0.001
	31–40 years	362	23.0	2541	20.3	
	41–50 years	411	26.1	2939	23.5	
	51–65 years	397	25.2	4100	32.8	
Income	US$0–25 000	349	22.1	2817	22.5	<0.001
	US$25 001–50 000	579	36.7	5417	43.3	
	US$50 001–75 000	250	15.9	2138	17.1	
	US$75 000+	398	25.2	2137	17.1	
	Missing	4	0.1	3	0.1	
Industry	Retail trade	123	7.8	1538	12.3	<0.001
	Educational services	249	15.8	916	7.3	
	Manufacturing	59	3.7	1082	8.6	
	Public administration	317	20.1	789	6.3	
	Healthcare and social assistance	186	11.8	902	7.2	
	Administration, support, waste management and remediation services	102	6.5	1067	8.5	
	Accommodation and food services	84	5.3	852	6.8	
	Construction	62	3.9	1026	8.2	
	Other	395	25.0	4343	34.7	
Job class	Sedentary/light	823	52.2	5759	46.0	<0.001
	Medium	338	21.4	2909	23.2	
	Heavy/very heavy	100	6.3	1186	9.5	
	Missing	316	20.0	2658	21.2	
Location	Rural	115	7.3	893	7.1	0.809
	Urban	1451	92.0	11 513	92.0	
	Missing	11	0.7	106	0.9	
Coexisting conditions	0	1418	89.9	11 274	90.1	0.944
	1–4	127	8.1	981	7.8	
	5+	32	2.0	257	2.1	
Outcomes						
Duration	Calendar days away from work, median (IQR)	36 (6–204)		40 (6–215)		0.1979
Cost (US$)	Median (IQR)	US$15 228 (3903–48 469)		US$16 737 (4020–46 859)		0.6326

WPV, workplace violence.

(92.0%). Injuries were evenly distributed across the years with 89.6% of claims closing by the end of 2019, and all claims closed by the end of 2022. The median leave duration was 40 days (IQR: 6–214 days), and the median cost of medical services and indemnity was US$16 580 (IQR: US$4000–47 067). The most common co-occurring codes by major category were disease of the musculoskeletal system (30.8%) led by spondylopathies/spondyloarthropathy; symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (18.9%) such as headache or migraine; mental, behavioural and neurodevelopmental disorders (9.8%) like neurocognitive disorders; and diseases of the nervous system (9.6%) such as pain.

In this study, 11.2% of mTBI claims were caused by WPV. When comparing WPV to non-WPV claims, the variables with statistically significant ($p \leq 0.001$) differences were age, income, industry and job class (see table 1). Those with a WPV claim tended to be younger, have higher income and be in the education, public administration or healthcare industries with sedentary or light physical demands at work. The three industries with the highest WPV mTBI claims had the largest proportion in the following locations: educational services—elementary and secondary schools (71.1%); public administration—correctional institutions (22.8%); and healthcare and social assistance—general medical and surgical hospitals (29.3%). There were no significant differences between the groups for sex, location, year, coexisting conditions or the duration of recovery. There were no statistically significant differences in the duration a person was away from work between the two groups (median 36 days vs 40 days, $p=0.1979$). The cost differences were not statistically significant (median US$15 228 vs US$16 737, p value=0.6326).

For the modelling of demographic and claim information's impact on the number of calendar days a person was away from work, a linear mixed model was used with the random effect being the NAICS major industry categories. The model included the categorisations of sex, age, income, job class, rural/urban and coexisting conditions (see table 2). Age and coexisting conditions were statistically significant variables in the model ($p<0.001$). The effects were all positive indicating that an increase in any of the categories would increase the leave duration when all other factors were held fixed, except for coexisting conditions which had a negative coefficient. That is, if a claim included WPV, was of an older age, had a higher income, had heavier work, was male or had fewer coexisting conditions, the expected mTBI work leave duration would be longer, although only age and

Table 2 A linear mixed model with industry as the random effect to explore impact on the number of calendar days a person is away from work due to a mild traumatic brain injury

	Estimate	SE	T value	P value
(Intercept)	3.19540	0.11674	27.371	<0.001
Workplace violence (WPV)	0.12329	0.06784	1.848	0.0646
Sex	0.11673	0.04626	2.523	0.0116
Age	0.30708	0.02119	14.556	<0.001
Income	0.00010	0.02111	0.005	0.996
Job class	0.06346	0.03131	2.027	0.0427
Rural/urban	0.06000	0.08200	0.732	0.4644
Coexisting conditions	−0.65095	0.05469	−11.902	<0.001

WPV was categorised as 0 if absent and 1 if present; age was categorised as 18–30, 31–40, 41–50 or 51–65 years; income was categorised as US$0–25 000, US$25 001–50 000, US$50 001–75 000 or US$75 001+; job class was categorised as 0 if sedentary or light work, 1 if medium work and 2 if heavy or very heavy work; rural/urban was categorised as 0 if rural and 1 if urban; sex was categorised as 0 if female and 1 if male; and coexisting conditions were categorised as 0 for none, 1 for one to four and 2 for five or more coexisting conditions.

coexisting conditions were statistically important across these variables. These were also modest estimates with coexisting conditions (−0.65) and age (0.31) having the largest impact.

DISCUSSION

To our knowledge, this is the first study examining US WPV mTBI claims and expands on prior work-related TBI research. We report three major observations from our study. First, we established that WPV accounted for 11.2% of mTBI claims during the study period from 2015 to 2019. Second, among those with WPV-related mTBI, those in the public administration and education services sector account for the most WPV-related mTBI claims at 20.1% and 15.8%, respectively. Finally, while WPV was not associated with a differing recovery duration, age and coexisting conditions were statistically associated with RTW outcomes.

The rate of 11.2% for WPV mTBI found in this study is higher than the studies from Canada, which found WPV TBI to account for 6.6% of claims, and Australia, which found 9% of mTBI claim caused by assaults in the workplace.[8 14] However, data may exhibit variability due to different definitions of both TBI classification and WPV because of the lack of an international standard.[28] We are unaware of data to suggest that the rates of WPV are higher in Canada or Australia versus the USA, which would suggest a greater exposure to potential injury.

The highest occurrence for WPV mTBI in this study was in public administration, followed by education and then healthcare and social services. Mollayeva *et al* found mTBI occurring most frequently in the healthcare and social services industry.[14] WPV in healthcare is important; in addition to significant research studies on the subject, US Congress passed legislation requiring WPV prevention training in 2021, and OSHA offers WPV training specific to nurses.[29–31] However, our study findings suggest that other industries may also benefit from WPV prevention.

While this study did not have data about workplace culture, it is possible that safety expectations at work may impact RTW, notably when working with vulnerable populations such as young children, incarcerated people or sick patients, the three most common WPV mTBI worksites in this dataset.[32] For example, research shows a high frequency of student-inflicted injuries among teaching staff in the educational service sector, especially surrounding special needs children.[33] Employers in these higher risk sectors could implement individual-level training, organisational practices and environment improvements to help prevent WPV and make the workplace safer.[34]

Contrary to our hypothesis that WPV would cause longer mTBI recovery times, there were not statistically different durations in recovery between those with WPV claims versus those with non-WPV mTBI claims. From our modelling, recovery may be related to age, job class, sex and the number of coexisting conditions. WPV, an uncommonly tracked variable, could be researched in other types of conditions like post-traumatic stress disorder where WPV was found to increase recovery durations,[7] While we did not see a difference in the prevalence of WPV mTBI claims across sex, it was trending towards significance in our mixed effects model (p=0.0116). Some researchers are exploring gender-specific care to improve equitable TBI outcomes.[35] Future research could review the medical care received or the timing of treatment to further explore the causes in these recovery durations.[25]

While there were no differences in the number of coexisting conditions between the WPV and non-WPV groups, this study found that more coexisting conditions resulted in shorter durations. Coexisting conditions are defined as any non-TBI ICD codes that appear on the claim, not synonymous with comorbidities. Further research is needed to determine whether the number of ICD codes on a claim correlates with case complexity (contrary to this study's results), or if it is instead an effect of medical coding and billing, access to care or other unknown factors.

Having a supportive employer or clinical team focused on RTW may help people recover.[36] One study found that work-related factors, such as demands or rewards at work, explained RTW success for mild or moderate TBI better than sociodemographic and injury-related predictors.[37] Due to the invisible nature of brain injuries, it is important that workplace accommodations support and validate the experience of injured workers with positive attitudes, gradual RTW and realistic modified duty expectations following TBI.[38]

Further research is needed to validate and qualify WPV by determining the source of the violence. This study relied on keyword searching and found WPV claims in many categories, such as fellow worker, patient or other person; struck or injured not otherwise classified (NOC); person in act of a crime; or other miscellaneous, NOC. Interventions to prevent violence would benefit from further details on the source of injury.

Limitations to this study include that workers' compensation claims are likely to be an under-reported measure of work-related disorders and industry-specific incident reporting trends cannot be measured from this data source.[39] This study did not include the number of people in each industry and may be affected by the proportion of the workforce in each industry, which could be the subject of future research.[40] There are varying definitions of TBI, which creates challenges when comparing global incidence and prevalence rates, as well as preventative efforts, clinical care and research.[28] Variables used in this study also had limitations, such as the high number of TBI-related ICD codes allowing diagnostic variability and only capturing coexisting conditions listed on the claim. Classifying WPV was dependent on free-text descriptions of the injury and is therefore likely to be affected by the accuracy and level of detail of the form's data collector. Removing claims without a release to work date may bias the data, either towards less severe claims that did not require entering an RTW date or more severe cases that did not RTW at the same employer either by choice or by medical necessity. One analysis was conducted to include those without a release to work date, as shown in table 1

(excluding the measurement of duration length), and another analysis was conducted to include imputed data for those with missing data, as shown in table 2, to test the impact of removing the missing data, and this did not change the direction nor magnitude of the findings. Missing data was not associated with the primary exposure with WPV being present in 10.5% of all cases versus 11.2% in only cases with an RTW date.

This study is the first to find that US workers may have higher risks of mTBI caused by WPV than other countries. However, the impact is mixed. Patients returned to work in the same timeframe for claims caused and not caused by WPV. These results can help employers and industries better understand who is at risk for WPV mTBI so that preventative measures can be implemented. WPV and job class were the only modifiable factors in the model and therefore should be the focus of additional research.

Contributors KW and WSJ conceived the study. KW, WSJ and DJ contributed to the project design. KW and JA completed the data management and analyses and drafted the manuscript. WSJ and DJ developed the implications for the findings. All authors reviewed, critically revised and approved the final manuscript. KW, as guarantor, accepts full responsibility for the finished work, had access to the data, and controlled the decision to publish.

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Data availability statement Data may be obtained from a third party and are not publicly available. The data that support the findings of this study are available from the WCIS, but restrictions apply to the availability of these data. More information is available here: https://www.dir.ca.gov/dwc/wcis.htm.

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