Examining Occupational Traumatic Brain Injury in Ontario

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ABSTRACT

Objective: Occupational traumatic brain injuries disrupt the lives of workers and carry major economic repercussions. To date, there has been limited information on brain injuries that occur at work across injury severity levels in Canada. The aim of this study was to provide an overview of occupational traumatic brain injuries in Ontario, with a focus on the sex of the workers.

Methods: For this cross-sectional study, data from the Ontario Workplace Safety and Insurance Board were used. A retrospective chart review was conducted of over 1,500 claim files from the year 2004 with the diagnostic codes of concussion and intracranial injury. Severity was assessed according to data on days off work.

Results: The average age of those injured was 37.8 years. The breakdown by sex shows that 57.8% of claims for occupational traumatic brain injury involved males. The most common mechanism of injury was being "struck by or against", followed by "falls". Most of the occupational traumatic brain injuries were from the manufacturing, and government and related services sectors. The highest rate, however, was shown for transportation and storage (81.5/100,000), followed by government and related services (56.6/100,000) and primary industries (47/100,000).

Conclusions: An examination of occupational traumatic brain injuries across a range of severities reveals a profile that is different from that associated with more severely injured workers: there were many more women in particular industries who were injured and more injuries involving being struck by an object. This paper provides data on key industries, mechanisms and contributing factors involved in work-related traumatic brain injury that result in claims to the Workplace Safety and Insurance Board.

Key words: Traumatic brain injury; epidemiology; workplace

La traduction du résumé se trouve à la fin de l'article.

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Traumatic brain injury (TBI) is a leading cause of death and disability worldwide. It is a very serious and often overlooked health care issue. Victims are often young, and survivors of TBI often live with devastating consequences, including temporary or permanent impairments, partial or total functional disability, psychosocial maladjustments and associated economic burdens.¹ Even mild injuries can have long-term consequences.² An examination of coroners' files in Ontario showed that approximately half of all workplace fatalities involved a brain injury.³ In a study by Kim et al.⁴ based on severe injuries identified from the Ontario Trauma Registry, it was found that hospitalizations involving work-related traumatic brain injuries increased by 12.4% from 1993 to 2001. Information obtained from the Workplace Safety and Insurance Board (WSIB) of Ontario revealed that the number of occupational TBI claims has nearly doubled over a span of eight years.⁵

Previous studies have examined severe/fatal^{3,4} or mild cases separately.⁶ To date, no recent study has investigated occupational TBI across levels of severity. Because of the number of negative repercussions associated with occupational TBI and the apparent rise in its occurrence, a comprehensive examination of occupational TBI across levels of severity is needed in the Canadian context. Additionally, men continue to represent the majority of fatal and seriously injured,^{3,4} therefore we hypothesize that men will display a more detrimental profile of occupational TBIs than women. Thus the objectives of this study were to provide an overview of occupational TBIs that includes factors associated with the injury, the

implication being that the results may assist in better targeting the prevention of work-related TBI, such as through sex-specific prevention.

METHODS

A case series design was used to examine all WSIB claims with an injury date in the year 2004 and categorized by the WSIB as either "intracranial injury" or "concussion". All fatalities categorized as "traumatic" were also examined, for evidence of traumatic brain injury. The WSIB data are based on approximately 70% of the total Ontario workforce and were abstracted using a form that drew upon Haddon's Matrix.⁷

In total, just over 1,500 non-fatal claim files were examined. Of those claims, 1,006 qualified as TBIs. Only claims with a confirmed

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Table 1. Rates of Injury (Concussion/Intracranial Injury) by Industry Sector (N=1,047)

Industry Sector	Frequency*			Denominator†			Rate/100,000		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Transportation and storage	84	26	110	102,130	32,905	135,035	82.2	79	81.5
Government and related	80	153	233	156,198	255,134	411,332	51.2	60	56.6
Other primary	30	‡	§	50,355	22,061	72,416	59.6	‡	47.0
Other services	79	73	152	203,383	255,349	458,732	38.8	28.6	33.1
Retail and wholesale trades	123	91	214	407,372	398,785	806,157	30.2	22.8	26.5
Construction	64	0	64	207,660	35,498	243,158	30.8	0	26.3
Manufacturing	162	78	240	708,400	327,712	1,036,112	22.9	23.8	23.2

* Includes non-fatal and fatal occupational traumatic brain injuries.

† Denominators for Other primary include mining, forestry, fishing and trapping, and agricultural and related industries; Government and related additionally includes health and social service industries; Other services additionally includes finance and insurance, business service, and accommodation, food and beverage industries.⁸

‡ Small cell size.

§ Not included to protect confidentiality.

diagnosis by a physician of “concussion”, “closed head injury”, “cerebral contusion” or “head injury with sequelae consistent with brain injury” were accepted for this study. A total of 94 “traumatic” fatality claims were also examined, 41 (44%) of which showed evidence of TBI as either a sole cause of death or as a contributing factor with other injuries. In total, there were 1,047 WSIB files that qualified for this study and that were examined in detail. Four major aspects of each claim file were examined when available, including Form 7, which is the employer’s account of the injury; Form 6, which is the worker’s account of the injury; Form 8, which is the physician’s first report; and medical documentation or memoranda that offered additional information.

Socio-demographic variables collected included age, sex, primary language, type of occupation and industry type. Injury characteristics collected were mechanism of injury, contributing factors and temporal factors. Outcome variables included lost time in days (e.g., days off work) as a surrogate of severity of injury and health care costs, which were obtained from an electronic data file from the WSIB. Claims were followed for one year after injury. Ten percent of fatal and non-fatal occupational TBI files were re-abstracted. Kappa statistics were conducted to assess for agreement between two abstractors. Excellent agreement ($\kappa \geq 0.80$) was found on core variables such as demographic variables and mechanisms of injury.

Statistical analysis involved generating frequency distributions for the total occupational TBI population and by sex, and calculating rates. Rates were calculated using, as the denominator, the number of males and females mandatorily insured in the Ontario labour force according to Standard Industrial Codes 1980 (SIC80), taken from the Labour Force Survey (LFS) 2000.⁸ Chi-square tests were conducted for categorical variables and *t* tests/Wilcoxon analyses for comparisons of continuous variables using SAS v 9.1 (Cary, NC). This study was approved by the research ethics board at the Toronto Rehabilitation Institute.

RESULTS

Table 1 shows the number of injuries and respective rates for both non-fatal and fatal occupational TBIs, by industry sector. The largest number of injuries occurred in manufacturing. The highest rates were shown for transportation and storage.

The overall breakdown by sex shows that 57.8% of occupational TBI claims involved males, whereas fatalities occurred almost exclusively among men. When sex and industry sectors were examined in detail, the largest proportion of women injured were working in the government and related services industry (66% of cases),

Figure 1. Distribution of injury mechanisms for occupational traumatic brain injury

followed by “other services” (48%). For non-fatal occupational TBIs, the average age of those injured was 37.8 years. Considering age and sex, females tended to be older than males, with an average age of 39.1 (standard deviation [SD]: 12.0) years and 37.2 (SD: 12.2) years respectively. By age and industry, workers in government and related services were the oldest (mean age: 41.6 years, SD: 11.5 years). Examining additional demographic data showed that, overall, most workers spoke English or French; however, 6% of seriously injured individuals did not, which was significantly higher than the proportion in the less severe groups ($p < 0.05$).

For non-fatal occupational TBIs, the main injury mechanism of most injuries was categorized as struck by or against an object (Figure 1). These injuries were categorized as struck by an inanimate object (35%), struck against an inanimate object (25%) and struck against building structures (15%). These types of injury involved banging heads on stationary objects such as machinery or equipment and objects falling on heads, including objects that had been misplaced or poorly mounted. Falls from the same level accounted for 21% of injuries and falls from elevation 8.7%. The former occurred mostly among service professions, such as home care nurses, letter carriers, customer service representatives and certain types of drivers. Falls from elevation often involved general labourers and skilled trades persons. Compared with women, men were notably more likely to experience a motor vehicle crash, a trend that was similar but less marked for falls from an elevation. For a number of the remaining conditions, men and women equally shared similar

Figure 2. Occupational traumatic brain injury by month **Figure 3.** Occupational traumatic brain injury: Time of day occurred

mechanisms of injury. Older workers were most susceptible to being struck and to falling, whereas for younger workers the injury was more likely to be of a struck by/against type of mechanism ($p < 0.001$).

The most common contributing risk factor was placement of objects in the working area (26.6%) and action or motion of the injured person (41.7%). Less common, with approximately 16% of injuries identified, were slippery conditions and the actions of other people (Table 2).

The seasonal and temporal trends for head injuries are shown in Figures 2 and 3 respectively. A higher number of injuries occurred in the winter months, and most injuries occurred mid to late morning (9:00-11:59 am).

The total number of days off work was 45,731.2, and men totalled more days off than women (29,648.9 vs. 16,082.3). Of the non-fatal occupational TBIs, 145 claims involved 60+ days off work. The average number of days lost for this study population was 46.0 (SD: 144.7) days, and the median number was 3.5 days, indicating highly skewed data and a tendency for fewer days off work. However, the range of days off work included values as high as over 1,130 days. Men averaged nearly two weeks more of lost time than females (men: 51.7 days, SD: 152.5 days vs. women: 38.1 days, SD: 133.3 days). The average health care costs were \$2,234.81 (SD: \$6,621.26), and the costs of non-health-care claims averaged \$4,676.38 (SD: \$15,752.29). It must be noted that the median of these outcomes was considerably lower, indicating a tendency for minor health care costs for this population. The range of values was as high as over \$66,545 for health care costs and \$130,500 for non-

Table 2. Contributing Factors for Occupational Traumatic Brain Injury (N=1,047)

Factors	Frequency (%)
Weather conditions	57 (5.7)
Slippery terrain	61 (6.1)
Slippery non-terrain	95 (9.4)
Other non-terrain walking surfaces	22 (2.2)
Placement of objects in working area	268 (26.6)
Change in elevation	31 (3.1)
Working overhead	47 (4.7)
Working in an elevated area	35 (3.5)
Working in a tight spot	129 (12.8)
Machinery, vehicle or tool malfunction	74 (7.4)
Time pressure	10 (1.0)
Actions of other people	165 (16.4)
Action of injured person	419 (41.7)
Other	128 (12.7)

health-care costs. The average health care claim was \$2,410.23 (SD: \$6,566.00) for men and \$1,990.37 (SD: \$6,698.00) for women. The highest health care costs occurred in the construction industry, at \$6,342.62 (SD: \$10,516.98), and the lowest in the transportation and storage industry, at \$1,702.91 (SD: \$4,889.00).

DISCUSSION

Occupational TBIs are a far-reaching problem that affects all industry sectors and demographic categories. This study provides a profile of occupational TBI in Ontario based on claims data to the Ontario WSIB, indicating industries with the highest number of occupational TBIs as well as the highest rates, and also providing information by age and sex. While only a small percentage of occupational TBIs contribute a major layoff and extremely high claim costs, hundreds of more minor injuries with 1 to 59 days lost add up to a formidable amount of overall working time lost, high health care costs and a disruption in the lives of workers.

This study is the only Canadian study to examine occupational TBIs for a range of severity levels, as indicated by days off work. It showed that by including all levels of severity, there was an equally high number of women affected by occupational TBIs in particular industries, a finding that might inform sex-specific prevention strategies. Women tend to be underrepresented in occupational TBI studies. However, they have unique post-injury signs and symptoms related to endocrine functions that warrant additional study and a focus on sex-specific workplace prevention strategies.⁹ Previous studies on more serious injuries were almost exclusively composed of males,^{3,4} whereas in this study females were well represented and their occupational TBIs included a range of severity.

Our findings on rates of injury by sector showed that workers in transportation and storage are most at risk of brain injury, followed by government and related services, and other primary industries. Our findings are different from those of previous studies on occupational TBI because of the inclusion of a range of severity levels in the study, whereas previous studies included severe hospitalizations⁴ or fatalities³ and showed other/primary industry as the sector with the highest rates. The relative ranking of industries involved in terms of occupational TBI in our study is most similar to that of Kristman et al.⁶ as a result of the inclusion of less severe occupational TBIs in general, although we used a less broad definition of TBI and did not restrict our population to only mild TBIs. We also see that age plays a role in terms of injury mechanisms, whereby older workers are more at risk of falls. Our results are consistent with work previously done on more seriously injured work-

ers.⁴ Our study, which includes many mild injuries, however, captures some of the injuries that most affect women.

Our study is one of the few that has examined the seasonal and temporal characteristics of injuries, and it showed peak instances of injury, which is very important information in a Canadian context. The study suggests how injury prevention strategies might take into account the variations of our weather, which likely influence injuries in the winter months perhaps during a work transition period. However, we recognize that this trend needs to be studied further by type of occupation and industry sector, as variations exist depending on the type of work involved.¹⁰ The study also indicates the need for good data on etiology that are specific to Canada. In addition, our data suggest that older workers versus younger workers may be more vulnerable to injury later in the day, possibly indicating the role of fatigue in injury.¹⁰ The occurrence of occupational TBI by age requires a closer examination. More consistent results across studies may be revealed once time of injury is taken into account.^{3,4,11,12}

In order to examine the scope of occupational TBI, a large population of this injury type is needed for examination. The Ontario WSIB offers coverage to roughly 70% of the workforce and is perhaps the best source of data for an epidemiological study of occupational TBI across severity levels. Files from the Office of the Chief Coroner in Ontario would provide more complete coverage of workplace fatalities in Ontario. ICD-10 coding used by hospitals more recently identifies emergency department visits and hospitalizations associated with workplace injuries and should also be examined; however, this would not capture persons who may have visited family physicians only.

For prevention-oriented studies such as this one, forms used for administrative purposes have the potential to be an excellent source of information, as it is easy to abstract and analyze data from them. The forms used for this study were Form 6, Form 7 and Form 8. Form 6 was only sparsely included in this set of files, many files relying solely on the report of the employer for a description of the injury. Form 7 was found to be included consistently and was the most reliable and most descriptive of all sources. This form typically included demographic information about the injured worker, as well as job- and injury-related information. While the overall quality of the data abstracted from this form was high, many forms were found to be incomplete despite legal requirements to complete the form in full. For cases in which information that should have been on file was missing or incomplete, memoranda were consulted in order to locate missing variables. Form 8 was supposed to be the first medical information on file. Before making a claim with the WSIB, one is required to have a Form 8 completed by a physician. Many files, however, were observed to have Form 8 missing. In addition to this, while most were properly completed, a sizeable number were incomplete. Often the form had an absolute minimum level of information. Past medical history was one of the variables found to be unreliable in this study, only a small percentage showing this information. The WSIB could greatly increase their ability to work towards epidemiological prevention efforts by better enforcing proper completion of forms on file or through ongoing training of personnel on form completion.

The WSIB codes head injuries as a priority over all other injury types. For instance, if a worker suffers both a TBI and a broken arm,

the claim will be coded as a head injury. This study used only claims coded as either "concussion" or "intracranial injury". Our estimates are likely conservative because we did not examine all files with other codes that might reveal a TBI, e.g., multiple trauma. Of the 1,503 files examined, only 1,006 qualified under the criteria used for inclusion in this study. Some claims had to be excluded because of lack of a positive medical diagnosis, but there were many that were simply miscoded. This was not formally recorded, but it was observed during the abstraction process that there was a fairly sizeable population of claims with a diagnosis of musculoskeletal injury type. Fatality claims were coded as either "traumatic" or "disease". It should be noted, however, that we did not examine a wide range of codes to see how many TBIs might have been captured under non-TBI diagnoses. We did not examine the multiple injury codes, which may have included TBI as well. Therefore, we believe that our estimates of TBI are conservative, as they pertain to only the two TBI codes examined.

This study addresses the dearth of data on occupational TBIs in Canada. It shows which sectors are most affected by this injury and provides information on mechanisms of injury. It also highlights the extent of lost time, indicating which industries have the longest days off work. Brain injuries can result in many days off work. Although many studies have focused on return to work after brain injury, there are virtually no peer-reviewed publications on the experience of returning to work after having an occupational brain injury in civilian populations. An examination of the facilitators and barriers of return to work after occupational brain injury is an important area for future research, which was beyond the scope of this paper. A previous brain injury is a risk factor for subsequent injury overall, but the extent to which this is true for occupational brain injury needs to be investigated. It is not known to what extent, for instance, workers/employers are trained to manage concussions in order to prevent further injury, as is occurring in other areas, such as the world of sports. These studies should include even mild injuries, as a subset of mild injuries can have persistent post-injury signs and symptoms that can worsen if the right steps are not taken to prevent further damage.^{13,14}

From our study, we advocate better reporting of the nature and circumstances of injuries so that the information can be used for prevention purposes. For future research, we recommend more detailed analyses of injuries as they occur across industries, with a focus on women. Future analyses should take into account the role of age in relation to mechanisms of injury and also temporal characteristics.

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RÉSUMÉ

Objectif : Les traumatismes cérébraux au travail désorganisent la vie des travailleurs et ont d'importantes répercussions économiques. Jusqu'à maintenant, on a peu d'information sur les niveaux de gravité des blessures cérébrales qui se produisent au travail au Canada. L'objectif de cette étude était d'en donner un aperçu pour l'Ontario, selon le genre des travailleurs accidentés.

Méthode : Pour cette étude transversale, nous avons utilisé les données de la Commission de la sécurité professionnelle et de l'assurance contre les accidents du travail de l'Ontario. Un examen rétrospectif de dossier a porté sur plus de 1 500 dossiers de demandes d'indemnisation en 2004 comportant les codes diagnostiques de commotion et de blessure intracrânienne. Nous leur avons attribué un niveau de gravité selon le nombre de jours d'absence du travail.

Résultats : L'âge moyen des personnes atteintes était de 37,8 ans. Réparties selon le sexe, 57,8 % des demandes d'indemnisation pour traumatisme cérébral avaient été déposées par des hommes. Les mécanismes de blessure les plus courants étaient d'avoir été « frappé par ou contre » quelque chose et d'avoir fait une « chute ». La plupart des traumatismes cérébraux au travail provenaient des secteurs manufacturier, gouvernemental et des services connexes. Le taux le plus élevé était par contre observé dans le secteur des transports et de l'entreposage (81,5/100 000), suivi des services gouvernementaux et services connexes (56,6/100 000) et des industries primaires (47/100 000).

Conclusion : Un examen des traumatismes cérébraux au travail selon l'étendue de la gravité dessine un portrait différent de celui associé uniquement aux travailleurs grièvement blessés : dans certaines industries, beaucoup plus de femmes que d'hommes avaient subi des lésions, et davantage de travailleurs accidentés avaient été frappés par un objet. Nous présentons nos données par grands secteurs d'activité, selon les mécanismes de blessure et selon les facteurs ayant contribué à des traumatismes cérébraux au travail entraînant des demandes d'indemnisation auprès de la Commission.

Mots clés : traumatismes cérébraux; épidémiologie; milieu de travail