J Rehabil Med 2004; Suppl. 43: 15–21

Taylor & Francis
healthsciences

MILD TRAUMATIC BRAIN INJURY AFTER TRAFFIC COLLISIONS: A POPULATION-BASED INCEPTION COHORT STUDY

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Objective: **To study the incidence and claim closure of traffic-related mild traumatic brain injury and the effect of insurance factors.**

Design: **Population-based, cohort study of mild traumatic brain injury caused by traffic collisions in Saskatchewan, Canada, between July 1, 1994 and December 31, 1995. On January 1, 1995 the insurance law changed from tort to no fault.**

Subjects: **657 adults, 18 years or older, who hit their head and indicated loss of consciousness or uncertain loss of consciousness and were not hospitalized for more than 2 days.**

Methods: **Subjects entered the cohort on the injury date and exited on the day the insurance claim closed, or on November 1, 1997, when remaining open claims were censored. All 657 subjects answered a baseline questionnaire, and 479 who did not reopen their claim were included in the follow-up. The relationship between claim closure and health was studied in 225 (47%) of these claimants.**

Results: **The 6-month incidence dropped from 36/100,000 to 27/100,000 after the insurance change. The median time-to-claim closure dropped from 408 days to 233 days. Prolonged claim closure was associated with both injury and insurance-related factors. Claim closure occurred faster when claimants' health improved.**

Conclusions: **Mild traumatic brain injury incidence and claim closure is affected by both health and insurance-related factors.**

Key words: mild traumatic brain injury, epidemiology, prognosis, compensation.

J Rehabil Med 2004; suppl. 43: 15–21

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INTRODUCTION

Even though road-traffic collisions are a common cause of mild traumatic brain injury (MTBI) in patients presenting to hospitals, there are few population-based estimates of the incidence of the problem. Most studies capture cases from the emergency room or after hospital admission, and these studies include cases that result from falls, assaults and other causes. The incidence rates in these studies vary, are not specific for traffic-related injuries and are difficult to compare because of the wide-ranging criteria used for case definition (1). Variability in case definition reflects the different criteria used to diagnose MTBI, which complicates any attempt to produce a unified definition to study the problem (2). In addition, there is some debate about the mechanisms of injury. For example, can MTBI result from acceleration/deceleration forces (whiplash) in the absence of blunt trauma to the head (3)? Even though patients with whiplash often complain of concentration and memory problems, these symptoms might be secondary to pain, rather than the result of a coup contra coup injury to the brain (4, 5). Until there is agreement on these issues, the results from incidence studies will vary with the case definition and inclusion criteria.

All of the above problems also apply to prognosis for MTBI after traffic injury. Although there are some good prognostic studies of MTBI, few differentiate prognosis by cause of injury (6). This issue is important since recovery after traffic injuries can be highly affected by unique factors related to injury compensation (7). For example, Ponsford et al. (8) identified having been injured in a motor vehicle collision as a poor prognostic factor for recovery in a cohort of patients with MTBI presenting to the emergency department. Paniak et al. (9) have shown a strong correlation between financial compensation and return to work in patients with MTBI. In whiplash injury to the neck, lawyer involvement and tort insurance are strong predictors of poor recovery (10). In general, psychosocial issues are at least as important as injury severity in determining the prognosis for the majority of those with road-traffic injuries (11). When compensation benefits are linked to pain and suffering, it can create a psychosocial barrier to recovery (12). Given the above, it is important to determine the incidence and prognosis for traffic-related MTBI and especially to assess the independent contributions of different prognostic factors.

Saskatchewan Government Insurance (SGI) is the only traffic injury insurer for the approximately 1 million residents of the Canadian Province of Saskatchewan. On January 1, 1995 the provincial insurance system changed from tort to no fault, eliminating payments for pain and suffering and decreasing

DOI 10.1080/16501960410023688

attorney involvement and court actions. The purpose of this study is to report the incidence and prognosis for a cohort of road-traffic injury claimants who had hit their head and experienced mild or uncertain loss of consciousness (LOS) and to investigate the effect of changing the compensation system on the incidence and time-to-claim closure. Finally, we also determine the effect of physical and mental health recovery on time-to-claim closure.

METHODS

Study population and design

We studied all traffic injuries that occurred in adults, 18 years and older, in the Canadian province of Saskatchewan between July 1, 1994 and December 31, 1995. This included all those receiving medical care, chiropractic treatment, massage therapy and physiotherapy for their injuries, and those that made an insurance injury claim, but did not seek treatment. Entry into the cohort occurred on the day of the injury and exit occurred at claim closure or November 1, 1997, when we censored all remaining open claims. From the 10,902 eligible claims opened during the 18-month study period, we excluded 292 fatalities, 113 workers' compensation claims, 81 non-English speaking residents, 86 subjects with more than 1 injury claim during the study period, and 69 seriously injured claimants (e.g. catastrophic head injury) along with 38 with illnesses unassociated with the injury (e.g. Alzheimer's disease) that precluded answering our questionnaires. Also excluded were 1010 incomplete claims, where individuals decided to drop their initial claim, and 207 where the claimant's lawyer advised them not to fully complete claims forms. We also excluded 529 claimants with more serious injuries that required hospitalization for more than 2 days. From the remaining 8477 claims, 657 met our cohort case definition for MTBI by answering yes to the question "Did you hit your head?" and answering yes or uncertain to "Did you lose consciousness after the collision?"

During the study period, we obtained de-identified baseline information from government insurance claim forms on all claimants. The majority (77%) of claimants filed their injury claim within 1 month of the collision and 90% filed within 62 days of the collision. We grouped questionnaire data into the 6 domains of socio-demographic, collision-related, initial health provider, initial symptoms, health-related, and pain-related variables. Consenting claimants completed an additional questionnaire on health-related quality of life (13) and mailed it to our research centre. Follow-up questionnaires were mailed to consenting claimants at 6 weeks, 4, 8 and 12 months after the collision. This included information about pain, symptoms and health-related quality of life. Pain intensity was measured on a visual analogue scale and the percentage of body area affected by pain was measured from a mannequin drawing (14, 15).

Outcome measures

The SGI administrative database provided time-to-claim closure for all claimants in an anonymous manner. This outcome is a common proxy for recovery in compensation studies (16–18) and represents the number of days on benefits, or until a final agreement is reached between the insurer and claimant. Claim closure usually coincides with the end of treatment or the attainment of maximal medical improvement and/or the end of income replacement. In some cases, claims are reopened to pay late accounts or because of symptom recurrence. SGI does not record the reason for re-opening claims, nor the first claim closure date in reopened claims in their administrative database. Therefore, our prognostic models are based on the 479 claims that were not reopened. We did this so our outcome would include only time on insurance benefits and not time between benefit periods.

We used follow-up data from the SF-36 summary scales to evaluate health recovery and its relationship to claim-closure (13). The physical component summary (PCS) is an aggregate measure of the physical conditioning, role-physical, bodily pain, general health, vitality, and social functioning scales. The mental component summary (MCS) is an aggregate of the general health, vitality, social functioning, role-emotional and mental health scales. The summary scales define distinct physical and mental clusters and account for 80–85% of the reliable variance in their component scales (19). Both the PCS and MCS possess good psychometric qualities, including test-retest reliability, discriminate validity and responsiveness to change in health status in those with various physical and mental illnesses, including MTBI (20–23).

A total of 225 claimants gave written informed consent to answer questions about health-related quality of life and to be identified and included in the follow-up portion of the study. The University of Saskatchewan's Advisory Committee on Ethics in Human Experimentation approved the study.

Statistical analyses

We calculated the 6-month incidence of MTBI using the 657 claims made during the last 6 months of the tort system and the first and second 6 months of the no-fault period. Age and gender-specific rates were calculated using the mid-year population as the denominator (24). We also calculated cumulative incidence using number of vehicle damage claims and million-vehicle-kilometres driven in Saskatchewan as denominators (25). Time-to-claim closure was calculated for the 479 claims that had not been reopened by using the Kaplan-Meier method. Incidence rates, closure times and baseline variables were compared across the 3 6-month insurance periods. Because there were no important differences in claim closure times or baseline variables between the 2 no-fault periods, they were combined in our analyses.

To investigate the impact of health recovery on time-to-claim closure, we built 2 time-varying covariate Cox proportional hazards models using follow-up data from the PCS and the MCS of the SF-36. These analyses were restricted to the 225 claimants who consented to our follow-up and had not reopened their claims. In these models, the values of the summary scales were updated over follow-up periods to investigate the impact of antecedent improvements in physical and mental health status on the rate at which claimants close their claims. Both models were adjusted for age, gender and other variables that caused the exposure estimates to vary by 10% or more (26). We then used the resulting model estimates to calculate the impact of improvements in physical and mental health on the rate of claim closure (18). This approach reflects the view that recovery is a multidimensional and dynamic process involving improvements in mental and physical health and not necessarily a fixed endpoint indicating "recovered" (27). In addition, we identified baseline factors associated with non-participation to the follow-up questionnaire using logistic regression, and then entered these factors into our models of health recovery to determine whether attrition biased our results.

Finally, we built a prognostic model for the 479 claims that had not been reopened using baseline variables in Cox models with claim-closure times as the outcome. Candidate variables were screened in crude and domain-specific models, retaining those variables with beta coefficients with $p \leq 0.10$ on the Wald test. The final multivariable model retained those variables with beta coefficients with $p < 0.05$. Results are reported as hazard rate ratios (HRR) and 95 % confidence intervals (CI), with a HRR of less than 1 indicating delayed claim closure.

We tested the proportionality assumption for time-varying models by examining extended Cox models (time-varying covariate and coefficient models), and plotted the log [-log (survival function)] against time to assess proportionality in our final prognostic model (28). All analyses were conducted using SPSS and SAS (29, 30).

RESULTS

During the study period, the 6-month incidence of MTBI claims decreased from 36 per 100,000 adults during tort to 25 and 29 per 100,000 adults during the first and second 6-months of no-fault. This occurred despite increases in the number of vehicle damage claims and million-vehicle-kilometres driven during this period (Table I). Overall, MTBI incidence rates were higher in males and the largest reduction in rates occurred in the youngest age group after the insurance change. For the 479

Table I. *Six-month incidence of mild traumatic brain injury by insurance period (n = 657)*

Variable	Tort	No-fault 1*	No-fault 2*
Total number of cases	260	185	212
per 100,000 inhabitants	36	25	29
per 10,000 vehicle damage claims	99	62	63
per 1000 million vehicle kilometres	44	30	35
Gender			
per 100,000 males	43	30	33
per 100,000 females	30	20	25
Per 100,000 inhabitants by age group			
18–23 years	90	53	65
24–29 years	54	37	35
30–39 years	30	24	25
40–49 years	31	20	22
>50 years	18	16	21

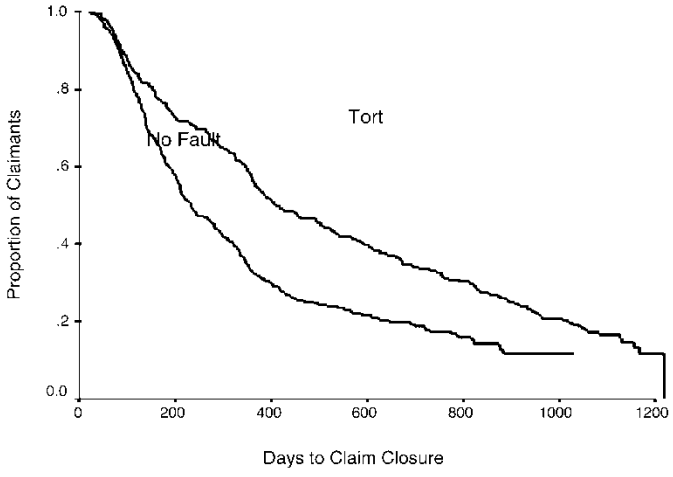
*No-fault 1 and 2 refer to the first and second 6 months of the no-fault period.

claimants with MTBI who had not reopened their claim, the median time-to-claim-closure was 408 days (95% CI 319–497) for tort claims and 233 days (95% CI 194–272) for no-fault claims (Fig. 1). These results indicate a 25% drop in the incidence of MTBI claims and a 43% decrease in MTBI claim closure times after the change to no-fault insurance.

We found some significant differences between claimants from the tort and no-fault periods (Table II). On the baseline questionnaire, more tort claimants (28.7%) indicated they had retained a lawyer than no-fault claimants (7.6%), and fewer tort claimants (15.7%) were at fault for the collision than no-fault claimants (23.8%). Fewer tort claimants (43.5%) had reported losing consciousness after the collision than no-fault claimants (56.7%), but more tort claimants were uncertain about it. Overall, tort claimants reported more intense headaches, neck pain and percentage of their body in pain than no-fault claimants. The vast majority of claimants were injured while in automobiles (89%), while the remaining were injured on motorcycles (3%), bicycles (3%) or as pedestrians (5%). Although most claimants went to the hospital emergency department because of their injuries (88%), only 27% were admitted overnight. Most of our MTBI claimants had multiple symptoms, including neck pain, headaches, dizziness and/or unsteadiness, low back pain and extremity pain and/or numbness (Table II).

Follow-up information on the SF-36 was available for 225 (47%) of the 479 MTBI claimants who had not reopened their claims. Non-respondents were more likely to be male, have less education, be represented by a lawyer and had excellent health before the collision. However, the median time to claim closure was almost identical for respondents and non-respondents (320 days for respondents and 324 days for non-respondents). For the 225 tort and no-fault respondents, our time-varying Cox models show that claim closure was highly associated with antecedent improvements in health status. A 10% improvement in physical health increased the claim closure rate by 59%, while a 10% improvement in mental health increased it by 45% (Table III). The crude and adjusted estimates from these models are similar, indicating that the relationships between physical and mental health status and claim closure are not confounded by known baseline factors, including those associated with non-response to the follow-up questionnaire. Overall, the impact of these measures of health status on claim closure is substantial, indicating that closure time is strongly influenced by physical and mental health recovery.

With respect to prognosis, delayed claim closure was independently associated with a variety of baseline factors in the 479 claimants with MTBI who had not reopened their claims (Table IV). These include marital status, work absenteeism, memory problems, nausea, percentage of body in pain, insurance system and fault for the collision. Of these, claiming



Days after claim	0–199	200–399	400–599	600–799	800–999	1000–1199	> 1200
Tort (n)	208	151	107	83	63	43	3
No Fault (n)	271	157	81	59	30	3	

Fig. 1. Kaplan-Meier estimates of the time-to-claim closure ($n = 479$).

Table II. *Baseline variable domains by insurance periods (n = 657)*

Domains Variables	Tort (*n* = 260)	No fault (*n* = 397)
SOCIO-DEMOGRAPHIC DOMAIN		
Age		
Mean age, years (SD)	36.3 (16.3)	38.8 (17.5)
Gender – n/total (%)		
Females	122/260 (46.9)	167/395 (42.3)
Marital status, n/total (%)		
Married or common-law	126/260 (48.5)	189/397 (49.9)
Single	105/260 (40.4)	153/397 (38.5)
Separated or divorced	21/260 (8.1)	32/397 (8.1)
Widowed	8/260 (3.1)	14/397 (3.5)
Number of dependants, n/total (%)		
No dependants	158/260 (60.8)	256/397 (64.5)
1 or 2 dependants	61/260 (23.5)	83/397 (20.9)
3 or more dependants	41/260 (15.8)	58/397 (14.6)
Annual family income, n/total (%)		
$60,000 or more	17/255 (6.7)	43/397 (10.8)
$40,000–$59,999	36/255 (14.1)	64/397 (16.1)
$20,000–$39,999	69/255 (27.1)	118/397 (29.7)
Less than $20,000	133/255 (52.2)	172/397 (43.3)
Education, n/total (%)		
<Grade 8	25/260 (9.6)	41/397 (10.3)
<High school	74/260 (28.5)	120/397 (30.2)
High school	71/260 (27.3)	103/397 (25.9)
Post-secondary	74/260 (28.5)	104/397 (26.2)
University graduate	16/260 (6.2)	29/397 (7.3)
Employment status, n/total (%)		
Full-time	127/260 (48.8)	219/396 (55.3)
Student	23/260 (8.8)	25/396 (6.3)
Part-time	43/260 (16.5)	56/396 (14.1)
Home-maker	23/260 (8.8)	38/396 (9.6)
Retired	19/260 (7.3)	24/396 (6.1)
Unemployed	25/260 (9.6)	34/396 (8.6)
COLLISION-RELATED DOMAIN – *n/total (%)*		
Lawyer involved	74/258 (28.7)	30/396 (7.6)*
At fault for collision	40/255 (15.7)	93/391 (23.8)*
Went to hospital	227/260 (87.3)	351/397 (88.4)
Hospital admission	72/259 (27.8)	101/395 (25.6)
Off work due to collision	174/256 (68.0)	250/394 (63.5)
Type of collision		
Automobile	229/256 (89.5)	346/392 (88.3)
Motorcycle	8/256 (3.1)	11/392 (2.8)
Bicycle	11/256 (4.3)	10/392 (2.6)
Pedestrian	8/256 (3.1)	25/392 (6.4)
INITIAL HEALTHCARE PROVIDER DOMAIN – *n/total (%)*[2]		
None	1/250 (0.4)	3/392 (0.8)
MD	186/250 (74.4)	305/392 (77.8)
DC	0/250 (0)	0/392 (0)
MD + DC	33/250 (13.2)	30/392 (7.7)
MD + PT	30/250 (12.0)	54/392 (13.8)
SYMPTOMS AFTER COLLISION DOMAIN – *n/total (%)*		
Headaches	225/259 (86.9)	329/395 (83.3)
Neck pain	241/260 (92.7)	359/397 (90.4)
Numbness/pain in arms/hands	137/260(52.7)	224/397 (56.4)
Low back pain	172/260 (66.2)	248/397 (62.5)
Numbness/pain in legs/feet	119/259 (45.9)	180/396 (45.5)
Jaw pain	72/259 (27.8)	117/397 (29.5)
Dizziness or unsteadiness	195/260 (75.0)	295/396 (74.5)
Nausea	122/259 (47.1)	175/397 (44.1)
Vomiting	33/259 (12.7)	48/395 (12.2)
Difficulty swallowing	48/259 (18.5)	73/397 (18.4)
Ringing in ears	89/260 (34.2)	131/397 (33.0)
Memory problems	107/258 (41.5)	147/396 (37.1)
Concentration problems	113/259 (43.6)	173/397 (43.6)
Vision problems	59/259 (22.8)	123/397 (31.0)*
Broken bones		
No	196/260 (75.4)	309/397 (77.8)
Uncertain	21/260 (8.1)	25/397 (6.3)
Yes	43/260 (16.5)	63/397 (15.9)
Loss of consciousness		
Uncertain	147/260 (56.5)	172/397 (43.3)*
Yes	113/260 (43.5)	225/397 (56.7)*
HEALTH BEFORE COLLISION DOMAIN – *n/total (%)*		
General health before collision		
Excellent	125/260 (48.1)	176/397 (44.3)
Very good	75/260 (28.8)	127/397 (32.0)
Good	55/260 (21.2)	71/397 (17.9)
Fair	3/260 (1.2)	19/397 (4.8)
Poor	2/260 (0.8)	4/397 (1.0)
Headache before collision		
Never	197/260 (75.8)	285/396 (72.0)
Sometimes	56/260 (21.5)	91/396 (23.0)
Very often	4/260 (1.5)	16/396 (4.0)
Every day	3/260 (1.2)	4/396 (1.0)
Tired and lack of energy before collision		
Never	185/259 (71.4)	289/397 (72.8)
Sometimes	63/259 (24.3)	84/397 (21.2)
Very often	4/259 (1.5)	16/397 (4.0)
Every day	7/259 (2.7)	8/397 (2.0)
Depressed before collision		
Never	231/260 (88.8)	342/396 (86.4)
Sometimes	23/260 (8.8)	41/396 (10.4)
Very often	3/260 (1.2)	9/396 (2.3)
Every day	3/260 (1.2)	4/396 (0.6)
Memory problems before collision		
Never	249/260 (95.8)	371/396 (93.7)
Sometimes	7/260 (2.7)	18/396 (4.5)
Very often	2/260 (0.8)	5/396 (1.3)
Every day	2/260 (0.8)	2/396 (0.5)
Concentration problems before collision		
Never	245/260 (94.2)	375/396 (94.7)
Sometimes	10/260 (3.8)	13/396 (3.3)
Very often	3/260 (1.2)	4/396 (1.0)
Every day	2/260 (0.8)	4/396 (1.0)
Prior road-traffic injury	77/260 (29.6)	123/397 (31.0)
Prior road-traffic injury to the head/face	22/248 (8.9)	28/303 (9.2)
PAIN FROM COLLISION DOMAIN		
Percentage of body in pain		
Number reporting	255	393
Mean percentage (SD)	29.0 (19.5)	26.1 (17.0)*
Headache intensity		
Number reporting	256	391
Mean score (SD)	45.2 (34.3)	35.6 (34.9)*
Neck pain intensity		
Number reporting	255	391
Mean score (SD)	54.2 (30.1)	48.6 (30.2)*
Other pain intensity[3]		
Number reporting	255	394
Mean score (SD)	52.0 (33.5)	49.3 (33.1)

*$p < 0.05$ for differences between tort and no fault using χ^2 statistic for proportions and *t*-test for continuous variables.
[1]Fault for collision assigned by Saskatchewan Government Insurance.
[2]Healthcare providers consulted within first few days after injury.
[3]Other pain intensity includes pain in the body other than neck pain or headache pain as measured on a 100 mm visual analogue scale.
MD = medical doctor, DC = doctor of chiropractic, PT = physiotherapist, SD = standard deviation.

Table III. *Associations between health status and time-to-claim closure (n = 220)*

	HRR (95% CI)	
Exposure	Crude	Adjusted
SF-36 Physical Component Summary Scale [1,2]	1.66 (1.39–1.99)	1.59 (1.28–1.97)
SF-36 Mental Component Summary Scale [1,3]	1.44 (1.21–1.72)	1.45 (1.18–1.80)

[1]Unit is a 10-point (10%) increase on the 100-point summary scale.
[2]Model adjusted for education level and neck pain intensity; 5 cases excluded because of missing values.
[3]Model adjusted for education level, lawyer involvement, previous injury to head/face, previous injury to arm(s), previous injury to back and neck pain intensity; 5 cases excluded because of missing values.
HRR = hazard rate ratio; CI = confidence interval.

under tort insurance and having 20% or more of your body in pain signalled the worst prognosis. After 1 year, 55% of tort and 32% of no-fault claims were still open, suggesting a prolonged claim process for many claimants.

DISCUSSION

Our analysis of MTBI after traffic collision in Saskatchewan indicates prolonged claim closure times that are dependent on physical, mental and social factors. These results confirm that insurance factors are just as important as injury severity in determining time on benefits. Furthermore, time-to-claim closure is associated with antecedent improvements in physical and mental health. Those who claimed under the tort system and those who are not at fault for the collision (victims) had a longer time-to claim closure, independent of other measures of injury severity. On average, no-fault claimants closed their claims 175 days sooner than tort claimants. These findings cannot be attributed to changes in treatment or rehabilitation, since primary care remained the main treatment during the study period, and organized rehabilitation programs were not widely available during the time of this study.

Table IV. *Factors associated with time-to-claim closure (n = 479)*

Factors	Crude HRR (95% CI)	Adjusted[1] HRR (95% CI)[2]
Marital status		
Married or common law	1.00	1.00
Single	1.59 (1.30–1.96	1.58 (1.27–1.96)
Separated or divorced	1.12 (0.78–1.61)	1.23 (0.84–1.80)
Widowed	1.15 (0.67–1.98)	1.05 (0.60–1.85)
Off work due to collision		
No	1.00	1.00
Yes	0.65 (0.53–0.80)	0.72 (0.57–0.89)
At fault for collision		
Yes	1.00	1.00
No	0.73 (0.57–0.92)	0.75 (0.59–0.96)
Insurance system		
No fault	1.00	1.00
Tort	0.62 (0.51–0.77)	0.65 (0.52–0.80)
Nausea after the collision		
No	1.00	1.00
Yes	0.67 (0.55–0.81)	0.76 (0.61–0.94)
Memory problems after the collision		
No	1.00	1.00
Yes	0.59 (0.48–0.73)	0.76 (0.61–0.96)
Percent of body in pain		
0–9%	1.00	1.00
10–19%	0.91 (0.68–1.23)	0.86 (0.63–1.17)
20–29%	0.64 (0.47–0.87)	0.64 (0.46–0.88)
30–39%	0.58 (0.42–0.81)	0.65 (0.46–0.92)
40–100%	0.46 (0.33–0.64)	0.61 (0.42–0.87)

[1]Hazard rate ratios are adjusted for all other variables in the model.
[2]21 cases excluded because of missing values.
HRR = hazard rate ratio; CI = confidence interval.

Most jurisdictions in North America and many in Europe currently operate under a tort insurance system. Our results suggest that more consideration should be given to the no-fault option. Under no-fault insurance, claimants receive compensation without prejudice to fault or the need to justify their injuries. Furthermore, payments are not made for pain and suffering, which can act as a disincentive for recovery. No-fault insurance also eliminates most court actions, which could also impact negatively on recovery.

Our findings also indicate that having more than 20% of your body in pain after the collision is associated with longer claim closure times. This is an important finding, since headache, neck pain and low-back pain are common after traffic collisions. Some authors have suggested that patients with whiplash can suffer from mild cognitive problems indicative of MTBI (3), and that patients with chronic pain suffer from post-concussion-like symptoms, including cognitive dysfunctions (4). This would suggest that there is not a sharp demarcation between these disorders and that clinicians need to be aware of overlapping and interacting clinical problems in patients with traffic injuries. Other studies suggest that much of the disability attributed to MTBI is greatly affected by associated musculoskeletal pain and injury (23, 31).

In our cohort, baseline nausea and memory problems were also independently associated with longer claim closure times. Other studies have documented their presence in acute MTBI, but few have examined their independent effect on prognosis (6). Since memory problems were self-reported by claimants, it is not clear whether they represent an objective cognitive problem or a more subjective finding that could be explained by other factors, such as associated stress and pain, or pain medication side-effects. In addition, being off work due to the collision was associated with slower claim closure, and being single was associated with faster claim closure. The interpretation of these findings is not clear, although early work absenteeism may be associated with overall acute injury severity. Also, in another study, we found that single persons cope less passively with pain than married individuals, and this could account for a better prognosis in these individuals (32).

We have previously described a 28% decrease in the incidence of whiplash claims in Saskatchewan after tort reform (10) and our present analysis shows a 25% decrease in MTBI claims after the insurance change. However, whiplash claims

were more common in women while MTBI claims are more common in men. In addition, the greatest decrease in whiplash claims was in men, while the decrease in MTBI claims did not appreciably differ by gender. These decreases occurred despite increases in the number of vehicle damage claims and the number of kilometres driven. They cannot be attributed to fewer claimants seeking healthcare, since there were no changes to access to care after tort reform and all persons requiring treatment for traffic injuries are reported to SGI by their attending clinicians. We are not certain why there are fewer claims under no-fault insurance, but the decision to make claim may involve factors beyond medical need, including financial gain or the desire for retribution. In the occupational injury setting for example, the best available literature suggests that a 10% increase in workers' compensation benefits is associated with a 1–11% increase in the number of claims (33).

In forming our cohort, we could not use clinical definitions of MTBI that include the Glasgow Coma Scale or length of post-traumatic amnesia. Instead, we relied on self-reported LOC, and identified MTBI claimants as those that reported having hit their head in a collision, had not been hospitalized for more than 2 days, and reported LOC or were uncertain if they had suffered LOC. This definition would exclude those with moderate and severe brain injury, who are routinely hospitalized for more than 2 days, but would also exclude those cases of MTBI with other serious injuries requiring longer periods of hospitalization and/or any other MTBI cases that remained in hospital for other reasons. In addition, our definition excludes MTBI with no reported LOC, MTBI without blunt impact to the head (i.e. due to acceleration/deceleration forces), and any cases that did not seek treatment and/or file an injury claim. We included those claimants who had hit their head, but were uncertain about LOC because they would probably represent those that were dazed by the impact or suffered a very brief LOC. However, excluding these cases and repeating our analyses on only those 260 claimants that reported LOC gives similar results (data not shown), indicating our findings are robust across definitions.

Despite the above limitations, our results are population-based and include all cases that attended any insured health-care practitioner (medical doctor, chiropractor, physiotherapist, and massage therapist) because of a traffic injury, or made an injury claim and did not seek insured care. Our cohort would not include anyone who was injured and did not seek insured care or make an insurance claim. It is likely that these cases would represent a very few mild injuries. Our annual incidence of MTBI claims due to traffic collisions is approximately 72/100,000 under tort and 56/100,000 under no-fault insurance. It is difficult to compare these rates to other studies because of our unique case definition and because our cohort was formed from traffic injuries only. However, given that traffic-related MTBI is a common cause for hospital admission (34) and the paucity of population-based research focused on traffic-related MTBI (1), we believe that further investigations should be undertaken.

A limitation of our study is the low response rate to the follow-up health questionnaires at 47%. However, we identified factors associated with non-response to the follow-up questionnaire and adjusting our health recovery models by those factors did not substantially alter our results. Furthermore, time-to-claim closure was not different for respondents and non-respondents. Since we had claim closure times for all members of the cohort, our results are not likely to be biased by attrition. We also had to exclude 178 reopened claims from our follow-up analyses. The median time for reopening of these claims was 30 days, and 38% were reopened and then closed within 1 week. This suggests that some of these claims were reopened for administrative reasons, such as paying a late account, rather than clinical reasons, such as recurrent symptoms. There were no significant baseline variable differences between the reopened and the other claims. In addition, if we were to include them in our analysis of claim closure times, our conclusions would not appreciably change (time-to-claim closure for 260 tort claimants: 490 days, 95% CI 396–584 and for 397 no-fault claimants: 329 days, 95% CI 297–361). Nevertheless, our multivariable model results might not generalize to those that reopen their claims due to symptom recurrence. Despite the attrition and exclusion of subjects from our prognostic models, we were able to consider and statistically adjust for a large number of important covariates, which would limit the effects of selection and/or confounding bias.

Our results should alert clinicians that traffic-related MTBI outcomes are dependent on both symptoms and insurance-related factors. In some settings, it might be difficult to resolve ongoing symptoms if insurance-related factors are impacting on recovery. Also, the relationships between head injury, pain and cognitive function are not well understood and require further research. Finally, researchers and policy analysts need to help governments and the public to understand that insurance laws could have an enormous impact on health recovery after traffic injuries. Given the prolonged time-to-claim closure in our claimants with MTBI, it is important to address all modifiable prognosis factors that could help these patients recover faster.

ACKNOWLEDGEMENTS

We thank Jon Schubert for advice about insurance matters, and we acknowledge the help of Diana Fedosoff and Shiley Tomchuk with data collection and administration.

This work was supported by a grant from Saskatchewan Government Insurance. Drs Cassidy and Carroll are supported by a Health Scholar Awards from the Alberta Heritage Foundation for Medical Research.

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