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ORIGINAL REPORT

FACTORS INFLUENCING SELF-RATED HEALTH IN TRAFFIC-RELATED MILD TRAUMATIC BRAIN INJURY

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Objective: **To report self-rated health and factors influencing health after traffic-related mild traumatic brain injury.**

Design: **Population-based, cross-sectional study of traffic-related mild traumatic brain injury occurring between 1 December 1997 and 31 November 1999 in Saskatchewan, Canada.**

Subjects: **Subjects were 929 adults making a personal injury claim after a traffic collision. Inclusion criteria were a head blow with certain or possible loss of consciousness or post-traumatic amnesia, or a possible head blow with certain loss of consciousness/post-traumatic amnesia. Excluded were those with loss of consciousness > 30 min and those hospitalized longer than 2 days.**

Methods: **Data were self-reported through insurance application forms completed within 6 weeks of the injury. Multivariable multinomial logistic regression was applied to identify factors associated with self-reported general health.**

Results: **In contrast to the 74.5% of subjects reporting excellent or very good health prior to injury, 70.8% reported having poor/fair health after the injury. Post-crash depressive symptoms, sleep problems, greater neck/low back pain and low expectations for recovery were associated with poorer post-injury health.**

Conclusion: **Those with traffic-related mild traumatic brain injury reported a decline in self-perceived general health. We identified potentially modifiable factors associated with poor post-injury health and suggested that these factors should be considered during early clinical intervention.**

Key words: mild traumatic brain injury, self-rated health, health-related quality of life.

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INTRODUCTION

Mild traumatic brain injury (MTBI) is the most common type of traumatic brain injury (1). It is frequently associated with short-term complaints such as headache, dizziness, fatigue, irritability, and concentration and memory problems. Some individuals with MTBI also experience persistent symptoms and related functional impairments (2–4). There are reports of some patients with MTBI having difficulties returning to or maintaining employment, serious disruption of social life, and increased incidence of depression or somatic illness (5, 6), even though the cause of these difficulties is sometimes not clearly understood. These could have a negative impact on the health-related quality of life (QoL) of persons with MTBI. Health-related QoL is multidimensional concept incorporating physical, emotional, and social components associated with an illness or its treatment (7). The investigation of health-related QoL has primarily focused on moderate and severe traumatic brain injury (8), and the issue of health-related QoL is still an under-studied area in MTBI research. Therefore, further research is indicated to explore the impact of MTBI on health-related QoL. It is important to identify factors associated with early recovery of MTBI since it could inform early care of the patients.

In health-related QoL research among MTBI, one major issue is the considerable variation in case definitions of MTBI. In addition, health-related QoL measures used to assess patients in studies vary, and there are differences among studies regarding how soon after injury patients were assessed (9). These variations pose difficulties in comparing and summarizing findings across studies. A few possible explanatory factors that have been proposed in different studies include post-concussion symptoms (especially depression and distress), poor physical functioning, pain intensity, limitations in usual role activities due to physical health problems, ethnicity, age, marital status, work status, intellectual capacity, pre-existing psychological problems and financial compensation (10–17). Given the heterogeneity of the relevant studies, it is necessary to explore population-based samples to examine a wide range of possible explanatory factors of health-related QoL among MTBI patients. "Self-rated health" is the individual's perceptions and evaluations of her or his health and has been accepted as one of the most important health outcomes for the assessment and management of patients. Self-rated health is often seen as a simple measure of health-related QoL. It can be assessed through a single question in which patients are asked to make general statement of their health (18).

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Saskatchewan is a province of Canada with a population of more than 1,000,000 and an average of 27,381 traffic collisions per year between 1999 and 2001. The majority of injury cases were non-fatal injuries (19), and these include cases of MTBI. Hence, research on this particular population will provide much needed information on traffic-related MTBI, which has been reported as the most common cause of MTBI by most of the countries for which data are available (20, 21). All Saskatchewan drivers and vehicles are insured by Saskatchewan Government Insurance (SGI), a provincial crown corporation company, the sole provider of personal injury insurance in Saskatchewan for those injured in traffic collisions. Moreover, healthcare providers in Saskatchewan are mandated to report all traffic-related injuries to SGI. Therefore, the traffic injury records from SGI capture traffic-related MTBI cases within the whole province.

The aim of this study is to report self-rated health of persons with traffic-related MTBI in Saskatchewan, and explore the factors influencing self-rated health after traffic-related MTBI.

METHODS

Study population and design

Baseline data includes all Saskatchewan residents, 18 years of age or older, who made a claim through SGI for a traffic-related injury that occurred between 1 December 1997 and 30 November 1999. This also includes all those seeking medical treatment for a traffic injury, since healthcare providers are mandated to report traffic-related injury to SGI for purposes of reimbursement.

We excluded those who died in the collision, those unable to answer the SGI questionnaires because of serious injuries (such as coma) or serious unassociated illnesses (such as Alzheimer's disease), and those who reported that they had lost consciousness for 30 min or longer (signaling a more serious brain injury) and those who were hospitalized for more than 2 days, as these were likely to have had more serious injuries than MTBI. Our cohort did not include those making a work-related traffic injury claim, since these individuals are covered under a different insurance system. Our cohort also could not include persons with traffic injuries who neither sought medical care nor made a claim.

Out of a total of 8634 Saskatchewan residents making personal injury claims during the study period, 1090 met the criteria for our primary operational case definition of MTBI. This involved stating "yes" to the question "Did you hit your head?" and either "yes" or "uncertain" to the questions: "Did you lose consciousness immediately after the accident?" and "Immediately after the accident, did you experience amnesia or loss of memory?" If they answered "uncertain" to the question "Did you hit your head?" but answered "yes" to the question "Did you lose consciousness immediately after the accident?" and/or "yes" to the question "Immediately after the accident, did you experience amnesia or loss of memory?", we also included them as MTBI cases. Finally, after further excluding those claiming more than 42 days after their injury (to ensure that we captured early rather than late onset symptoms), 929 remained as our primary subject group for exploring factors associated with self-rated health.

Given the unavailability of clinical diagnoses in this database, misclassification of cases as MTBI is possible. In order to assess the robustness of the primary case definition, an alternative case definition was established for a further sensitivity analysis. Based on the same exclusive criteria above, 723 individuals who met the criteria of the alternative definition were identified for the purposes of remodeling all the explanatory factors. These individuals answered "yes" to either or both of the questions: "Did you lose consciousness immediately after the accident?" and "Immediately after the accident, did you experience amnesia or loss of memory?"

Measures

Self-rated health was assessed by a single item question: "In general, would you say your health is now: excellent, very good, good, fair, or poor?" This is an item from the SF-36 (18), a commonly used health-related QoL instrument. It has been demonstrated that self-rated health is a valid, reliable, holistic health measure in numerous population groups including those with MTBI (10, 22).

Pain intensity was measured by the 11-point numerical rating scale (NRS-11). This is widely used, both in clinical practice and research, and has proven reliability and construct validity (23, 24). The Co-morbidity Scale was applied to measure co-morbid medical conditions. This is a self-report questionnaire to assess the presence of health effects of 12 co-morbid health conditions, including diabetes, cardiovascular disease and gastrointestinal disorders. This questionnaire has good reliability and has been validated against physician reports and health-related QoL (25). It has been used in a number of studies to adjust for case mix (26–28). The presence of depression symptoms was assessed by the Center for Epidemiological Studies Depression Scale (CES-D), which is a self-report questionnaire widely used in clinical and large epidemiological studies as a screening tool for depression. It has been found to be valid, reliable and sensitive in the general population as well as in the TBI population (14, 29).

Statistical analyses

Descriptive analysis was applied to investigate the self-rated general health reported by 929 traffic-related MTBI subjects who filed claims within 42 days of their injury. Self-rated health during one month before the injury was also examined for comparison.

Multivariable models were used to identify factors associated with self-rated general health. Multinomial regression was chosen to build the model, using self-reported health as the outcome variable. In this model, self-reported poor health was the reference category, and each of the other health states (fair health; good health; and excellent or very good health) was compared with the reference group. All analyses were carried out using SPSS Version 10.0. (SPSS computer program, Version 10.0 Chicago: SPSS: 1999).

In order to maximize statistical power and enhance the precision of our estimates, the following analysis strategies were applied. First, 62 potential explanatory factors were divided into 6 "domains" of conceptually related factors. These domains are: demographic and socioeconomic factors; collision-related factors (such as position in vehicle, direction of impact, post-crash attendance at hospital or emergency roo); pre-injury health (such as general health prior to the crash, prior injuries, prior treatment for musculoskeletal conditions); co-morbid health conditions (such as high blood pressure, other medical conditions); post-crash symptoms; and pain location and intensity. Other factors considered as potential explanatory factors were expectation for recovery, initial healthcare provider and number of days between the injury and completing the claim form. These factors were selected on the basis of both theoretical interest and prior research that had identified them as important. We then used each explanatory factor individually to assess its univariable association with self-rated health. Those associated with self-rated health at a significance level of $p \leq 0.1$ (using the Wald statistic) were retained in the next step; that is, they were included in the domain-specific multivariable models (30). We then examined the p-value of the Wald statistic in the domain-specific multivariable models, and retained those factors whose association with health was significant at $p < 0.1$ level. For those variables with $p > 0.1$, we further assessed their importance by calculating the changes of –2 Log Likelihood for the domain specific model when the variable was removed from this model. If the change in the estimate of the effect was greater than 15% after removing that factor, it was also retained in the domain-specific model. Thirdly, we assessed the presence of interaction effects by

examining all first-order interactions between the explanatory variables; and interactions between gender and all included variables. A final model was then built using those variables retained from previous procedures. Factors associated with self-reported health at a $p < 0.05$ level of significance were retained in the final model.

Finally, we repeated this analysis strategy using the cohort based on the alternative case definition of MTBI, in order to assess the sensitivity of our findings to the primary definition.

RESULTS

Descriptive analysis

A description of the study population is reported in Table I. Of the 929 traffic-related MTBI claims who made their injury claim within 42 days of the collision, median time between the injury and completing the claim form was 11 days. At the time of making their claim, 27 (2.9%) reported excellent health, 47 (5.1%) reported very good health, 196 (21.1%) reported good health, 374 (40.3%) reported fair health, and 283 (30.5%) reported poor health. When subjects were asked about their general health one month before injury, a larger proportion of them reported excellent health (42.3%) and very good health (32.2%), while only 0.8% subjects rated their prior health as poor.

Table I. *Sociodemographic characteristics of subjects (n = 929)*

Sociodemographic factors	*n* (%)
Age, years, mean (SD)	38.2 (16.7)
18–24	252 (27.1)
25–34	211 (22.7)
35–44	201 (21.6)
45–94	265 (28.5)
Female gender	
Female	463 (49.8)
Male	466 (50.2)
Marital status	
Single	371 (39.9)
Married/common law	413 (44.5)
Widowed	33 (3.6)
Separated/divorced	112 (12.1)
Number of dependents	
0	562 (60.5)
1–2	237 (25.5)
3 or more	130 (14.0)
Education*	
Grade 8 or less	75 (8.1)
Grade 9–11	252 (27.2)
High school	228 (24.6)
Some post-secondary	188 (20.3)
Technical school	111 (12.0)
University graduate	74 (8.0)
Annual income, $ Can**	
0–20,000	378 (41.7)
20,001–40,000	268 (29.5)
40,001–60,000	149 (16.4)
> 60,000	112 (12.3)
Employment status	
Full-time	423 (45.5)
Part-time	126 (13.6)
Student	59 (6.4)
Homemaker	54 (5.8)
Retired	79 (8.5)
Unemployed	49 (5.3)
Off work (not due to injury)	20 (2.2)
Other	119 (12.8)

*One case missing from education.
**22 cases missing from annual income.
SD: standard deviation.

Multivariable analysis

Forty-two factors had a univariate association with self-rated health at the significance level of $p < 0.10$, and were eligible for inclusion in the multivariable models. Six domain-specific models were built to examine sociodemographic factors, collision-related factors, pre-injury health, co-morbid health conditions, post-crash symptoms, and pain due to collision respectively.

In all, the 6 domain-specific multivariate models yielded 30 possible explanatory variables to retain in building the final model (Table II). Of these, the factors associated with poorer self-rated health at the time of the claim included older age, not seeking healthcare immediately after the collision at a hospital or emergency clinic, poorer health one month before injury, past motor vehicle injury claim, depression, dizziness, sleep problems, restriction of daily home activities, greater neck/shoulder pain, greater low back pain, lower expectation for recovery and choosing a medical doctor as the only initial healthcare provider.

In the final model, age was the only sociodemographic variable associated with self-rated health, with the youngest persons (age 18–24 years) with MTBI rating their health as much better than the oldest individuals (age 45–94 years). Those who went to hospitals or emergency clinics immediately after the injury were more likely to have fair self-rated health rather than poor health compared with those who did not go to hospital or emergency clinic (odds ratio (OR) 1.6; 95% confidence interval (CI) 1.0, 2.8). Individuals who reported excellent health before the injury were more likely to rate their post-collision health as excellent/very good (OR 3.2; 95% CI 1.6, 6.4) or good (OR 1.9; 95% CI 1.0, 2.4), while this association did not appear for the level of fair self-rated health. Similarly, significant associations were present between "having had no past motor vehicle injury claim" and reporting excellent/very good or good health. Depressed individuals were less likely to report excellent/very good, good and fair health as opposed to poor health. A 1-point increase in depression score was associated with a 4–9% increase in the odds of experiencing poor health. Individuals without post-crash dizziness were more likely to rate their health as excellent/very good and good rather than poor. Those who had no sleep problems were more likely than those with sleep problems to rate their health as good. Individuals without restriction of home activities were more than twice as likely to report excellent/good health than those having such restrictions. Individuals with neck/shoulder pain and low back pain were more likely to report worse self-rated health than individuals who did not have the pain. Expectation for recovery was strongly associated with concurrent measures of self-rated health. Individuals who expected a quick recovery were much more likely to also report better current health than poor health, whereas individuals who did not expect recovery or were uncertain about their expectations were likely to report

Table II. *Results of final model: odds ratio (OR) and 95% confidence intervals (CI) for variables associated with self-rated health of people with MTBI (n = 888)**

Factors	Poor health	Excellent + Very good health OR (95% CI)	Good health OR (95% CI)	Fair health OR (95% CI)
Age group, years				
18–24	1	2.5 (1.1, 6.0)	2.9 (1.5, 5.7)	2.7 (1.6, 4.5)
25–34	1	1.2 (0.5, 3.1)	2.5 (1.3, 4.9)	1.5 (0.9, 2.5)
35–44	1	1.0 (0.4, 2.5)	1.4 (0.7, 2.8)	1.5 (0.9, 2.4)
≥45	1	1	1	1
Hospital or emergency				
No	1	1	1	1
Yes		0.8 (0.3, 2.0)	1.2 (0.6, 2.4)	1.6 (1.0, 2.8)
Health one month before injury				
Excellent	1	3.2 (1.6, 6.4)	1.9 (1.0, 2.4)	0.9 (0.6,1.4)
Not excellent	1	1	1	1
Past motor vehicle injury claim				
No	1	2.9 (1.0, 8.0)	2.1 (1.1, 3.9)	1.4 (0.9, 2.1)
Yes	1	1	1	1
Depression score mean	1	0.91 (0.87, 0.94)	0.94 (0.92,0.96)	0.96 (0.95, 0.98)
Dizziness				
No	1	2.4 (1.2, 4.8)	2.0 (1.2, 3.4)	1.5 (0.9, 2.3)
Yes	1	1	1	1
Sleep problems				
No	1	1.6 (0.7, 3.4)	1.9 (1.0, 3.6)	1.6 (1.0, 2.8)
Yes	1	1	1	1
Daily home activities				
No	1	2.1 (1.0, 4.2)	1.7 (1.0, 2.9)	1.0 (0.5,1.6)
Yes	1	1	1	1
Neck/shoulder pain	1	0.74 (0.66, 0.84)	0.79 (0.72, 0.86)	0.86 (0.80, 0.93)
Low back pain	1	0.87 (0.78, 0.97)	0.83 (0.77,0.90)	0.92 (0.87, 0.97)
Expectation for recovery				
Get better soon	1	13.6 (4.7, 39.7)	8.5 (3.3, 21.8)	4.3 (1.7, 10.4)
Never get better/do not know	1	0.4 (0.2, 0.8)	0.3 (0.1, 0.4)	0.5 (0.4, 0.8)
Get better slowly	1	1	1	1
Initial healthcare provider†				
MD only	1	1	1	1
MD + one or more others	1	1.0 (0.4, 2.5)	1.7 (1.0, 3.0)	1.8 (1.2, 2.8)
Others	1	3.3 (1.1, 9.8)	3.1 (1.3, 7.8)	2.3 (1.0, 5.1)

*For continuous variables, 2 decimals were kept for illustration.
†Healthcare providers consulted within first few days after injury.
MD: medical doctor.

poor health. Finally, the type of healthcare provider seen in the early days after the crash was also associated with self-rated health. Individuals who sought care from medical physicians and one or more other types of healthcare providers, such as chiropractor, physical therapists and massage therapist were more likely to report fair health than poor health. Individuals who sought healthcare from other healthcare practitioners were likely to rate their health as excellent/very good, good or fair (instead of poor) compared with individuals who visited physicians only.

Findings were similar when this model was reproduced using a dataset based on the alternative MTBI definition. Since there were fewer subjects, the precision of the estimates is lower; that is, the confidence intervals were wider.

DISCUSSION

Our findings suggest that the perceived general health of individuals with traffic-related MTBI declines, at least in the short term, after MTBI. In our multivariate model, we found that only age was important factor among all the demographic and socioeconomic factors. Those aged 18–34 years were likely to rate themselves as having better health than people in older age categories. The importance of age in self-rated health after MTBI has been underscored in past findings (11–13, 15). Among individuals who went to hospital or emergency immediately after the collision, fair health was more often reported. This may be a result of available early interventions, as indicated by Borg et al. (31). However, due to limited information on the precise clinical treatments that subjects actually received initially, no conclusions could be reached regarding whether and which early interventions affect self-related health. Interestingly, initial healthcare provider has a significant concurrent association with the post-injury health of individuals with MTBI. Those who chose a medical doctor as the only initial healthcare provider were more likely to report poor health. This might be due to a tendency of more seriously injured persons to go to a medical doctor rather than

another healthcare profession. Unfortunately, given the cross-sectional nature of this study, it is impossible to make confident inferences on the causal direction of these 2 factors.

People who reported excellent health for the month before the injury were also likely to report excellent/very good or good post-injury health, regardless of injury severity factors. This suggests that prior health is an important factor to assess, both in a clinical setting and for research purpose, as it is predictor of post-injury health. These findings suggest that it may be helpful for physicians to be aware of patients' previous health status during patient assessment and intervention. Furthermore, there was a strong association between having had no prior motor vehicle injury and good to excellent health. This suggests that prior injuries may be a risk factor for poorer short-term outcome after MTBI, possibly due to the continued existence of complications from prior injuries, such as neck pain from previous motor vehicle collision, as suggested by Côté et al. (27, 28).

Depression had a weak association with poor self-rated general health. Although self-perceived poor health status has been reported to have an associated with the onset of the new episode of depression in a general adult population (32), we cannot make causal inferences in this study because both factors are ascertained at the same time. Thus, it is not clear whether depression leads to, or results from, poor health. An association between depression and health-related QoL is also supported by findings from other studies on MTBI subjects (12, 33). Therefore, depression is an important factor to consider during intervention after MTBI.

Emanuelson et al. (10) suggested that persisting symptoms after MTBI might be a causal factor in the declined health-related QoL of people with MTBI. Findings from our study support the suggested association. Dizziness and sleep problems are associated with poorer post-injury health. However, other physical symptoms, such as headache and fatigue, had no association (in our multivariable analysis) with post-injury health after MTBI. Ability to carry on daily home activities was associated with excellent/very good health. Therefore, daily home activities may be a simple variable to assess instead of a variety of subjective MTBI symptoms when monitoring the general health of MTBI patients. In addition, expectation of recovery is very strong factor that is significantly related to self-rated general health. Expecting to recover quickly is associated with excellent/very good/good health rather than poor health, and expecting to recover slowly or not at all is associated with poor general health. This finding raises the possibility that encouragement about the likelihood of recovery may be a simple means of improving the general health of individuals with MTBI. However, given the concurrent measurement of these factors, it may also mean that individuals took their current perceived health into consideration when making judgments about how quickly and how well they would recover.

Pain is important component of health-related QoL. In our study, neck/shoulder pain (OR 1.2, 95% CI 1.3, 1.4) and low back pain (OR 1.2, 95% CI 1.2, 1.1) were found to have significant associations with poor health. However, given the high prevalence of neck/shoulder pain and low back pain in traffic-related MTBI cohorts (16), and the high degree of pain reported after a whiplash injury (34), these factors are worth attention when studying health-related QoL of MTBI or motor vehicle collision samples. Neck/shoulder and low back pain may be effective factors to target in order to improve the health-related QoL of individuals with MTBI. All the findings above were further supported when using the alternative MTBI definition.

This study has some limitations. First, although financial compensation factors have been shown to be important in recovery (16, 35), the impact of these factors could not be explored in the current context, since all subjects in this study were seeking compensation. In addition, all were covered under the same insurance system (a no fault system with no payment for pain and suffering and little scope for litigation), with the same insurance provider, and all information reported in this study was captured at the beginning of the claim process, thus no compensation decisions had yet been made. Secondly, the current study employed a cross-sectional design. It limits our ability to infer a causal or predictive relationship between the factors and self-rated general health. Prospective studies with a control group are then indicated for further assessment of these findings. Finally, possible misclassification of MTBI cases and non-cases could have occurred in this study. However, the fact that modifying our case definition for MTBI yielded no important differences in the identified factors increases our confidence in the validity of these findings. Overall, this study has important research and clinical implications. Understanding the identified factors may assist researchers in further exploring predictive or causal factors of self-rated general health after MTBI and provide helpful information that healthcare providers need while they treat or assess MTBI patients. Early interventions targeting identified modifiable factors could be the most effective approach to minimize the negative impact on the general health of MTBI patients who report persisting symptoms and complaints.

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