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Vocational Outcome Indicators in Atypically Recovering Mild TBI: a Post-Intervention Study

*Fanny Guérin, Ph.D.^{1,2}, Stephan Kennepohl, Ph.D.^{1,4}, Geneviève Léveillé, erg.¹,
Aysha Dominique, erg.¹ & Michelle McKerral, Ph.D.^{1,2,3,*}*

¹ TBI Program, Centre de réadaptation Lucie-Bruneau, ² Centre de recherche interdisciplinaire en réadaptation, ³ Department of Psychology, Université de Montréal, and ⁴ Montreal Neurological Institute, Montréal, Québec, Canada

Abstract: Beyond issues of MTBI etiology, a key question remains the characterization and early identification of those individuals at risk of poor functional outcome. Using a retrospective analysis, the current study aimed at identifying the specific indicators related to return to work in adults with both symptomatic MTBI and functional impacts, having completed a specialized intervention program. In terms of outcome, 59.1% of the cohort (n=110) returned to some form of work-related activity by the end of intervention whereas the rest had not. Three of the sixteen variables studied were retained (logistic regression) as providing unique and significant ($p < 0.05$) contributions to the prediction outcome model, namely age, number of subjective symptoms and the presence of a public insurance provider. There was also an interaction between the presence of a public insurance provider and referral delay. Overall percentage of cases correctly classified by the model was 70%, positive predictive accuracy was 72.9%, whereas negative predictive accuracy was 65%. Our findings suggest that any studies attempting to assess functional outcome need to take account of the multifactorial nature of MTBI, including not only more objective psychological/physiological variables related to the injury, but also subjective complaints and environmental factors.

Keywords: mild traumatic brain injury, post-concussion symptomatology, vocational outcome, prognostic indicators

*Correspondence to: Michelle McKerral, Ph.D., Centre de recherche interdisciplinaire en réadaptation-Centre de réadaptation Lucie-Bruneau, 2275 Laurier Avenue East, Montréal, Québec, Canada H2H 2N8; Tel.: +1 514 527-4527, ext. 2530; Fax: +1 514 527-0979; e-mail: michelle.mckerral@umontreal.ca

Introduction

Of all traumatic brain injuries occurring each year in North America, approximately 85% are considered mild in severity [2,5]. It is estimated that anywhere between five and 15% of all individuals having suffered a mild traumatic brain injury (MTBI) are at increased risk of developing chronic symptoms, but there is controversy on the actual rate of poor outcome following MTBI [1,7,18]. This controversy can, in part, be explained by the fact that the outcome measures used in many studies focus on symptom manifestation and evolution, and/or on neuropsychological function rather than on actual level of functioning [29]. It has been shown that symptomatic MTBI can be associated with long term functional limitations, such as difficulty in returning to and maintaining active employment [12,17,28,32,36]. This atypically recovering sub-population at risk of poor functional outcome remains to be specifically characterized, as clearly underlined by the recent MTBI literature [7,18,30]. The latter, although a relative minority compared to all MTBI cases, can result in considerable societal costs [4,8].

General understanding of MTBI has evolved considerably over the past decade or so, particularly as pertaining to the more typical post-trauma recovery pattern [7]. The initial symptomatology following MTBI can be complex for example, physical, cognitive or emotional in nature, and may result in changes in overall functioning within the first few weeks following the injury [13,20,21]. Several studies have suggested that the initial symptoms identified up to the first month post-MTBI can directly attributable to injury-related pathophysiological factors [14,18]. These can be objectified with a variety of measures including formal neuropsychological evaluation, electrophysiology and

functional neuroimaging [3,9,15,26,27]. Nevertheless, ascribing a precise cause to the appearance of early post-MTBI symptoms remains difficult [18,22].

Attributing causality to more persistent post-concussion symptoms becomes even more problematic, particularly if one considers the possibility that the underlying etiology of overt symptomatology may vary over time [21,23]. Indeed, there is increasing agreement that various personal, psychological and environmental factors not directly related to the initial pathophysiological alteration itself can play a significant role in both the appearance, subsequent maintenance of symptoms and of physical or cognitive incapacities [3,7,21,35,38]. The early symptomatology, environmental challenges and functional impacts represent cumulative stressors which can negatively influence the self-perception of performance capabilities and hinder functional recovery [21,35,38].

Beyond issues of etiology, it has become evident that a key question remains the early identification of those individuals at risk of poor outcome, as well as the nature, timing, and intensity of potential interventions [16,30,38]. Various indicators predicting chronic symptomatology or functional outcome following MTBI have been proposed. It is generally agreed that the determinants of such symptomatic MTBIs are multifactorial in nature: they can be physical/neurological (e.g., GCS score, previous TBI), psychological (e.g., either pre- or post-injury coping) or environmental (e.g., marital status, involvement of litigation) [20,21,24,25,29]. However, the presence of persisting symptoms does not necessarily imply difficulties in everyday activities; it is thus the weight and interactions

between such variables in regards to symptomatology as well as functional outcome which need to be better understood.

One of the most studied outcome measures following MTBI has been return to work, as persistent unemployment following MTBI represents an important cost, both to the individual and to society as a whole [4,8]. Return to work has been shown to be a good measure of social participation [12,32]. However, given the number of possible variables, it has been extremely difficult to obtain a clear picture of the factors representing the best indicators of vocational outcome following MTBI. For example, some researchers have proposed that age can be an important moderating variable with respect to return to work following MTBI, arguing that older people may have more trouble re-entering the workforce in general [17,37]. However, others have suggested that this relationship may actually be reversed under certain conditions. For example, Drake *et al.* [12] report a more favourable prognosis for older individuals in the military (possibly because of their higher rank), and suggest that some degree of decision-making freedom at work seems to be conducive to going back to work after MTBI [36]. Various studies have concluded that specific factors such as gender or level of education may or may not be significant predictors of a successful return to work following MTBI [10,12,17,32,36,37].

Although a prior history of neurological or psychiatric problems is often cited as a predictor of a negative outcome following MTBI, such findings have not been clearly borne out in the literature, at least in terms of return to work [17,32]. Some authors also

suggest that specific injury-related factors associated with the mechanism of trauma (e.g., object falling on head) or the cause (assault vs. motor vehicle accident) may also be related to vocational outcome [10]. Interestingly, injury severity, as defined by either Glasgow Coma Scale scores or duration of post-traumatic amnesia, has generally not been considered a good indicator of employment outcome following MTBI. Lower scores on certain neuropsychological tests, especially attention and memory, particularly in the early phases of recovery have also been proposed as significant predictors of poorer return to work [17]. One relatively consistent finding has been the correlation between the number and severity of subjective complaints, even several months after the trauma, and return to employment [e.g., 10,23]. Others have suggested that the presence of depressive symptoms following the accident may also interfere with work reentry [17]. Ruffolo *et al.* [36] report that individuals who have maintained a certain level of social interaction six to nine months post-injury have a better chance of returning to work.

In recent years, several authors have made a strong case for the potential importance of issues related to litigation in MTBI and their influence on outcome [3,7]. However, such a relationship is not invariably found, some authors [17,32] suggesting that this may depend on sample selection, for example litigation as a means of recognizing and treating injury-related problems vs. an attempt to obtain financial compensation.

One of the key reasons for the conflicting findings regarding vocational outcome in the literature may well be the significant differences in the MTBI sample under consideration [7,29]. In addition to the controversies surrounding the precise definition of MTBI, many

studies do not consider those that do not recuperate well as a separate group, potentially masking strong effects. Furthermore, potentially important factors such as depression or significant pain often serve as exclusionary criteria in MTBI studies. Although some may argue that this represents a necessary step in understanding 'pure' MTBI, it might also limit the clinical applicability of such findings to this distinct subgroup [29,30].

The province of Québec, Canada, provides a somewhat unique setting for the study of outcome following MTBI. In Québec, there exists a continuum of province-wide and publicly-funded rehabilitation services, often, but not exclusively, in partnership with various government agencies such as that providing automobile insurance (Société d'Assurance Automobile du Québec - SAAQ), workers' compensation (Commission pour la Santé et Sécurité au Travail - CSST) and compensation for victims of criminal acts (Indemnité pour les victimes d'actes criminels - IVAC). Such public insurance gives access to these services and provides salary replacement to specific individuals who incur their injury as a result of a motor vehicle accident, work-related accident or assault. This typically consists of approximately 80% of all MTBI cases referred to specialized intervention programs such as the one in which the present study was conducted. The other 20% of the clientele has no public or private insurance covering the cost of rehabilitation services, but some have private insurance providing partial salary replacement.

Although this remains somewhat controversial, there is a degree of consensus that some form of formal intervention is warranted for this particular subgroup showing atypical

recovery, even if not for the MTBI population as a whole [6,30,38]. In the context of the continuum of services in Québec, a number of outpatient rehabilitation centers have developed specialized intervention programs for symptomatic MTBI individuals having difficulties in everyday activities, with a specific emphasis on vocational issues. This context offers the possibility of assessing and treating this sub-group within a more comprehensive set of trauma-related services than those offered exclusively in the emergency or acute setting. One of the primary goals is the collaboration between neurotrauma and rehabilitation centers in the early identification of these individuals and rapid referral for intervention when indicated. Systematic medical screenings are carried out in order to establish early diagnosis and functional prognosis. Consequently, this context of specialized clinical intervention services represents an ideal setting to specifically study the MTBI subgroup at risk of poor long term outcome, particularly in terms of the relative weights and interactions between the many variables, including those modifiable by intervention as well as those that are not, that modulate outcome.

Objective

The objective of the current study was to identify, using a retrospective analysis, the specific indicators related to return to work in a group of individuals with both symptomatic MTBI and functional impacts, having completed a specialized intervention program.

Methods

Sample selection

The sample consisted of all individuals (n=110) with a MTBI diagnosis (defined as a Glasgow Coma Scale [GCS] greater than 13 and a loss of consciousness of less than 30 minutes (with or without a positive scan) who had completed a specialized post-MTBI outpatient intervention program between 1999 and 2004 in one of the major rehabilitation centers in Montreal, and who were employed at the time of their injury. All were initially referred by public insurance providers, acute trauma centers or private medical clinics because they showed a disproportionate initial psychological reaction and/or demonstrated slowed functional recovery, for example both persisting post-concussive symptomatology and difficulty in maintenance/resumption of vocational activities at 1 month post-trauma.

Specialized MTBI intervention program

The above outpatient MTBI clinical services were developed on the basis of the existing MTBI literature. Since systemic evidence-based methods for the treatment of MTBI have not been formally developed, the treatment program was created on the basis of theoretical models that attempt to encompass the complex multidimensional nature of MTBI [21,38]. Both the evaluation procedures and interventions consider the different individual and environmental factors that may affect a person's recovery prognosis as well as the resumption of daily activities [16]. Intervention may minimally focus on education and coping strategies, as well as reassurance regarding the typical recovery

following MTBI. If not sufficient for functional improvement, a more specific and supportive approach is used.

The treatment is conducted by a small multidisciplinary team that may or may not include clinicians from the following specialties: medicine, psychology/neuropsychology, social work, occupational therapy, and physiotherapy. The make-up of the treatment team is based entirely on the individual's specific needs and clinical profile, and rarely includes members from all of the above disciplines. As a general rule, this approach attempts to identify and target a single, overarching problem that seems to affect daily living; this 'common denominator' represents the core of the intervention on which clinicians act simultaneously, either directly or indirectly, in an effort to reach the short-term objectives identified by the client and clinicians. A framework for return to work is devised as soon as possible by providing support both for the employer and the person in the workplace. Until individuals go back to work, they are encouraged to maintain close links with their employment milieu and to stay in touch with work colleagues. While return to work is often the primary objective, domestic and leisure activities are also the object of clinical interventions.

Note that these interventions differ quite significantly from those used with moderate or severe TBI. For example, they are not as frequent or intensive, and may not deal directly with cognitive functioning.

Variables of interest

All data were obtained from specific intake or initial evaluation reports in the rehabilitation and/or medical files. Sixteen factors were identified based on the prior literature and coded into 24 independent variables, either dichotomous (absence, presence) or continuous, for subsequent analysis. These variables were of four types, namely demographic, physiological/neurological, subjective/psychological and environmental. Demographic factors included age, gender, years of education, and language of use (French or English). Sixteen physiological/neurological variables were chosen, including: initial GCS score (13, 14, 15, not available); direct impact to the head or not; CT findings (positive, negative, not available); pre-injury neurological diagnosis (2 dichotomous variables: prior TBI, other neurological condition); pre-injury chronic health problem (e.g., diabetes); associated injuries incurred during the trauma (3 dichotomous variables: presence of significant internal injury, neck injury, other musculoskeletal injury); and significant post-traumatic pain (2 dichotomous variables: post-traumatic headache, other injury-related pain). Subjective/psychological factors consisted of total number of subjective symptoms upon admission, absence/presence of pre-injury psychiatric diagnosis or diagnosis of post-injury anxiety or depression. Environmental factors included the delay between the injury and the start of intervention (in months) and the absence/presence of a public insurance provider. Subjective symptoms were specified, based on symptoms at program admission, from the Rivermead Post-Concussion Symptoms Questionnaire [24].

Vocational outcome was defined as a dichotomous variable dependent on whether or not the individual returned to work-related activities (full-time or part-time employment, in school, searching for work) at the end of interventions.

Data analysis

Given the exploratory nature of the current study, a backward logistical regression was used to assess the relationship between the above-mentioned variables and return to work. This type of analysis has the further advantage of decreasing the number of variables of interest for use in future research. Logistic regression was preferred to other methods of analysis such as discriminant function analysis because of its flexibility (e.g., use of both categorical and continuous variables) and the fewer assumptions regarding the nature of the underlying data.

Results

Descriptive statistics

The cohort included 70 men and 40 women (n=110). Mean age of the sample was of 37.4 years (SD=10.5) with a mean educational level of 13.4 years (SD=3.5). On average, individuals reported a total of six post-concussive symptoms upon admission (SD=2.2).

The frequencies for each of the categorical variables are presented in Table 1.

Insert Table 1

A number of these findings are worthy of mention. French was the primary language of use in the vast majority of cases (over 93%); given the very uneven distribution between language groups, this variable was not retained in subsequent analyses. A total of 38 individuals, almost 43% of those for whom such data were available, had a positive finding on the initial CT scan. Many reported some type of significant post-traumatic pain at admission: over 70% reported significant post-traumatic headaches and over 85% reported significant pain in other parts of the body. Just over 70% had a diagnosis of mood or an anxiety disorder at the time of admission. The majority (85.5%) of the individuals in our cohort had a public insurance provider, primarily following a motor vehicle accident (68%), a work-related injury (15%) or an assault (2.5%). The remaining 14.5% of subjects (16/110) did not have insurance covering the cost of services, but 6 individuals had partial private salary replacement. Finally, delay between injury and referral ranged from 2 weeks to 3 years post-MTBI, with a median of 3.3 months.

In terms of outcome, well over half ($n=65$; 59.1%) of the individuals were considered to have returned to some form of work-related activity by the end of intervention, whereas 45 (40.9%) had not. Of those returning to some type of vocational activity, 41 returned to full-time work (37.2% of the total sample), 13 returned to work part-time (11.8% of total) and 11 were in school or looking for employment (10.1% of sample).

Logistic regression model

A backward iterative logistic regression was conducted in order to identify statistically significant ($p<0.05$) predictors among available variables. A total of 16 steps were

executed, resulting in a three-factor prediction model. A summary of the log-likelihood goodness-of-fit statistics for this model is provided in Table 2, and a more detailed description of the obtained model coefficients is presented in Table 3.

Insert Table 2

Insert Table 3

As indicated, three variables were retained in the model as providing unique and significant contributions to the prediction model, namely age, number of subjective symptoms and the presence of a public insurance provider. Among the non-indicators of note were: gender; years of education; GCS score; CT scan results; mechanism of injury; associated physical injury and pain; post-injury anxiety or depression; as well as pre-injury medical, neurological or psychological problems and referral delay ($p > 0.05$).

Table 4 summarizes the classification table produced using the above model. The overall percentage of cases correctly classified by the model is 70%. The positive predictive accuracy (% of cases correctly predicted as returning to work) was 72.9%, whereas the negative predictive accuracy (% of cases correctly identified as not returning to work) was 65%.

Insert Table 4

In order to more fully understand the relationship between return to work and the variables of interest, a second backward logistic regression was conducted to assess the possible importance of interactions between the variables mentioned above. The resulting model not only confirmed the importance of these variables (i.e., age, number of subjective symptoms, presence of a public insurance provider) on vocational outcome, but also yielded an interaction between the presence of a public insurance provider and referral delay.

Discussion

The objective of the current study was to assess the importance of various factors in predicting eventual return to work in a group of individuals with atypical recovery following MTBI. Our results indicate that 60% of the studied cohort shows a positive vocational outcome. This group can be distinguished from those having not returned to work at the end of rehabilitation on the basis of three factors: age, number of subjective symptoms and presence of a public insurance provider.

Our findings are largely consistent with the existing literature on return to work following MTBI. First, our results suggest that increasing age was significantly associated with a decreased probability of returning to work. Although this has not always been the case in previous studies with MTBI [17,22,24,28,29], it is important to note that age remains an important predictor of poorer outcome after TBI in general [e.g., 33,11]. In fact, we found a cut-off of approximately 40 years of age beyond which individuals seemed to

demonstrate poorer functional outcome, a result which is also in line with the TBI literature [19,31].

The results of the current study are also in accordance with prior findings indicating that the number of subjective complaints can serve as a useful predictor of outcome following MTBI [10,23]. More specifically, those reporting 6 symptoms or more at intake appeared to manifest a greater risk of eventual unemployment at the end of treatment. These results suggest that subjective complaints should not be underestimated or minimized by the alert clinician, even in the absence of more objective medical or psychological findings, since our results also show that the latter were not an indicator of poor vocational outcome.

One particular finding of this study was the significant relationship between the presence of a public insurance provider and return to work. More specifically, those who had a public insurance provider were approximately seven times less likely to return to work than those that did not. This difference cannot simply be attributed to group differences associated with one or more variables in the model (e.g., age, subjective symptoms, or delay of referral), as logistic regression specifically assesses the unique or uncorrelated contribution of each of the variables in the model. This does not, however, rule out potential group differences along other lines, including the specific reasons of the initial referral or the increased motivation to return to work in the absence of a full salary replacement. The finding of an interaction between the referral delay and the presence of a public insurance provider further complicates the latter's role in regards to outcome.

Interpretation of these results is limited by the particular outcome measure, vocational, used in the present study. Furthermore, it is not possible to determine whether the presence of a public insurance provider and/or early referral are related to higher long-term maintenance of work-related activities.

Given the inclusion of a large number of potential variables in the initial model, some of the more interesting findings pertain to the absence, rather than the presence, of a significant relationship with eventual employment. The present investigation did not reveal a significant relationship between return to work and any of the neurological, physiological, and psychological factors related either to premorbid status (e.g., previous TBI or other neurological condition, premorbid psychiatric condition) or the injury itself (e.g., presence of positive findings on CT scanning, Glasgow Coma scale, post-accident pain). Moreover, there was no correlation between the presence of a post-MTBI diagnosis of a mood or anxiety disorder and vocational outcome. Arguably, the fact that all individuals in the current study were actively engaged in an intervention program, which necessarily included access to psychological and physical interventions, could have reduced the functional impact of emotional, cognitive or physical problems on eventual outcome, for example by promoting better coping strategies. This hypothesis remains to be prospectively verified within the MTBI sub-population showing atypical recovery. The latter would permit to respond to the critiques emanating from the recent reviews pertaining to post-MTBI intervention [6,30].

The model retained is also interesting in terms of its specific ability to predict return to work. Overall accuracy of the current model was approximately 70%, suggesting that the model constitutes a significant improvement compared to chance. However, there remains considerable unaccounted variance, an observation that here again underscores the immense complexity underlying MTBI. Furthermore, the model does not seem equally suited to all forms of prediction, faring somewhat better at indicating who will eventually return to work (positive predictive value of almost 73%) compared with those that will not (negative predictive value of 65%). However, it might be argued that a more conservative model such as this is preferable in the current clinical context, as the disadvantages of a false positive error (i.e., predicting that someone should be able to work when they cannot) would seem to outweigh the problems associated with a false negative error (i.e., predicting that someone will not return to work when they can). In the latter case, referral of such an individual would simply lead to faster recuperation, re-evaluation of prognosis and earlier end of interventions.

Before applying such a decision model into clinical practice, further investigations should be made in order to confirm the present findings by establishing cross-validation of the model obtained. In spite of the moderate sample size, we specifically chose to conduct a large number of analyses to allow for a much broader and inclusive, if somewhat more liberal, overview of potential predictor variables; this will allow for a more focused assessment in follow-up studies. Although a large number of variables were evaluated, there remain a number of potentially important factors that were not included. For example, we specifically chose not to include cultural factors in the current analyses

given the inherent complexities of appropriate classification and identification (particularly when using retrospective analysis). However, socio-cultural factors or other factors related to ethnicity could potentially have a substantial impact on functional outcome [36]. Furthermore, prospective longitudinal studies will permit a more detailed outcome measure that better defines workers' realities, such as the ability to maintain work over an extended period of time and the complexity of work-related tasks.

Also, return to active employment represents only one of a number of possible measures of outcome assessing different aspects of general functioning, including an individual's ability to perform daily living activities, persistence of symptoms, or more general issues concerning overall health and quality of life. It may well be that the factors specifically related to return to work may not be the same as those associated with other equally important areas of functioning.

Although the particular context for TBI rehabilitation in Québec allows for quite a broad sampling of individuals with MTBI, issues remain with regard to the generalizability of the present findings. Some have argued that many who suffer a MTBI, including a proportion of individuals with persistent symptoms, do not present to the emergency room [18]. And while potentially quite representative atypically recovering MTBI, our sample also presents a number of specific characteristics that might reduce comparability with other studies studying outcome following MTBI. It should be recalled that a significant proportion of the current cohort had positive findings on initial CT (43% of those for whom such information was available) and that the vast majority, over 85%,

had some type of significant injury-related pain that did not directly involve trauma to the head. Comparative prospective studies in different intervention contexts should be conducted in order to verify their specific impacts on return to work. In fact the latter could demonstrate that in the majority of clinical milieus, those receiving post-MTBI interventions fit the above characteristics and thus represent the complex MTBI sub-population which is at greater risk of poor outcome. Nonetheless, our results indicate that the more specific study of the 40% of our cohort showing poor outcome despite having received interventions is warranted. Hence, the relationship between subjective symptoms and various measures of post-MTBI functional outcome need to be further investigated, and particular care should be taken as to the specificity of the populations studied in order to draw appropriate conclusions.

Finally, it is important to mention that identification of specific predictors does not, in and of itself, imply causation. Given the complexity and multidimensional nature of MTBI, simplistic interpretations of the current findings should necessarily be avoided. For example, although there can be little doubt that subjective complaints can serve as a significant predictor in empirical studies, the precise etiology underlying such symptomatology can, and does, remain a matter of intense debate. There are similar considerations when interpreting findings related to the presence or absence of a third-party payer. On the basis of our findings, it might certainly be tempting to conclude that the simple presence of a public insurance provider can have an adverse impact on return to employment. However, it is certainly possible, and perhaps even probable, that a predictor such as the presence of a public insurance provider can serve as a more

convenient and measurable proxy for some other latent causal factor – the present results should be interpreted as a reflection of the overall context in which empirical predictions can be made without necessarily specifying the cause.

In conclusion, our study suggests that it is possible to predict, with a substantial degree of success, the probability of return to work in atypically recovering MTBI using a straightforward logistic regression model. Our findings strongly suggest that any studies attempting to assess functional outcome need to take account of the multifactorial nature of MTBI, including not only more objective psychological/physiological variables related to the injury, but also subjective complaints and other environmental factors that might affect functional outcome. Further prospective research carefully documenting and measuring the above in the context of intervention will help to determine the best early clinically meaningful prognostic indicators and to direct MTBI individuals for necessary and sufficient interventions when needed. It will also permit direct evaluation and improvement of existing specialized MTBI intervention practices.

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Table 1: Table of frequencies for each categorical variable

Variables		Frequency	
Demographic	Gender	Male	70
		Female	40
	Language of use	French	7
		English	103
Physiological/ neurological	Glasgow Coma Scale (/15)	13	12
		14	24
		15	48
		N/A	26
	Direct head impact	Absent	39
		Present	71
	CT-scan findings	Negative	51
		Positive	38
		N/A	21
	Prior TBI	Absent	100
		Present	10
	Other premorbid neurological condition	Absent	102
		Present	8
	Premorbid health problem	Absent	75
		Present	35
	Internal injuries	Absent	96
		Present	14
	Neck injury	Absent	84
		Present	26
	Musculoskeletal injury – other	Absent	45
Present		65	
Post-traumatic headaches	Absent	32	
	Present	78	
Other Pain	Absent	16	
	Present	94	

Subjective/ psychological	Premorbid psychiatric diagnosis	Absent	86
		Present	24
	Post-injury anxiety or depression	Absent	39
		Present	71
Environmental	Public insurance provider	Absent	16
		Present	94

Table 2: Overall model summary

-2 log likelihood (deviance)	Model Chi-square (log-likelihood)	df	Significance level
127,889	20.947	3	.000

Table 3: Description of the model coefficients

	Odds ratio	Sig.	Exp. (B)	Lower limit	Upper limit
Age	0.057	0.007	1.059	1.016	1.104
# subjective symptoms	0.260	0.012	1.297	1.060	1.588
Presence of public insurance provider	2.058	0.013	7.834	1.539	39.878

Table 4: Classification of MTBI individuals according to the model

	Predicted return to work		Total
	Yes	No	
Return to work			
Yes	51	14	65
No	19	26	45
Total	70	40	