Prediction of outcome following mild traumatic brain injury

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2017

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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Prediction of return to work up to one year after mild traumatic brain injury: A multifactorial approach including occupational factors

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Accepted for publication in Neurology
ABSTRACT

Objective
To study return to work (RTW) after mild traumatic brain injury (mTBI) at 3, 6 and 12 months after injury, taking into account complete (cRTW), partial (pRTW) and no RTW (nRTW), thereby reporting on long-term sustainability of work. Furthermore, studying predictors for RTW at 6 and 12 months after injury with predictors in different categories (demographic factors, injury related factors, post-injury stressors, and occupational factors).

Methods
Prospective longitudinal cohort-study (UPFRONT) including all patients with mTBI at the ED. Included patients received questionnaires at 2 weeks, 3, 6, and 12 months after injury.

Results
Rates of cRTW increased from 34% at 2 weeks to 84% at 12 months after injury, pRTW varied from 8-16% throughout the year. Patients shifted between all categories of work resumption, even after six months. With logistic regression we demonstrated that apart from previously identified predictors such as the presence of extra-cranial injuries, age, education, cause and severity of injury, and indicators of psychological distress, occupational factors were of influence for work resumption after 6 months, while at 12 months the model was solely based on the presence of extra-cranial injuries, and indicators of maladaptation after injury.

Conclusion
RTW after mTBI is a gradual process, with shifts through different levels of RTW throughout the first year after injury. Patients resume activities despite posttraumatic complaints. These complaints, and the presence of signs of psychological distress already early after injury may help in predicting which patients will encounter problems with short and long-term RTW. Return to work is a multifactorial process, in which patient, injury and occupational factors play a role.
INTRODUCTION

With an estimated incidence of 600 per 100,000 persons per year, mild traumatic brain injury (mTBI) is a major public health problem.\(^1\) Especially during the first weeks of recovery, mTBI can have profound impact on daily functioning. Posttraumatic complaints (PTC) such as headache, dizziness or forgetfulness are reported by approximately 85% of patients during the first weeks after injury, and may interfere with daily routines.\(^2\) Return to pre-injury vocational activities is an important parameter for outcome, and while it is acknowledged that most mTBI patients return to work (RTW) within weeks to months after injury, an estimated 5-20% struggles with work resumption in the chronic phase after 6 months post-injury.\(^3\) This loss of work productivity accounts for a large part of mTBI related societal costs.\(^4\) Therefore, being able to accurately predict already in an early phase after injury which patients will encounter problems with RTW is one of the most important endeavors in mTBI research.

In several reviews on the subject of RTW after mTBI it is concluded that RTW rates vary widely between studies,\(^3,4\) mostly due to methodological differences. One of the contributors to heterogeneity of results is the applied criterion of work resumption; differences in levels of RTW are often not addressed. RTW may be defined as a complete resumption of pre-injury vocational activities, as a partial return at lower capacity, or as no return to work. Nevertheless, although this variation in methodology, multiple outcome studies led to the identification of factors influencing RTW in patients with mTBI as displayed in Table 1. Problems with work resumption are thought to be caused by both demographic factors (e.g. age, gender, educational level, and marital status) and injury characteristics (such as cause of injury, injury severity, presence of extra-cranial injuries, and CT-scan abnormalities) combined with post-injury stressors such as anxiety, depression and posttraumatic stress. Although it seems intuitive to consider also occupational factors in the prognostic models of RTW, these factors have received little attention over the years. Walker and colleagues reported that patients conducting pre-injury manual labor pre-injury were less likely to RTW when compared to skilled or professional/managerial functions, thereby demonstrating that work-related factors should be incorporated in prediction models.\(^5\) In 2014, the WHO collaborating task force urged the need for more high quality research on occupational factors in relation to RTW after mTBI.\(^3\)

Although it is acknowledged that a small percentage of patients does not return to work 1-2 years after injury, studies focusing on differences in predictors between short and long-term vocational integration are sparse.\(^6\) Moreover, the majority of patients that resume work still report PTC, raising the question whether these patients will develop problems in a later phase, outside the scope of most studies conducted up to 6 months
after injury. Sustainability of employment is therefore another important question at hand, and it is debatable whether the same predictors apply for short- and long-term work resumption.

The objectives of this study on RTW after mTBI were twofold. The first aim was to identify RTW rates at 3, 6 and 12 months after injury. We focused not only on complete and no RTW, but also on partial RTW, thereby assessing long- and short term work resumption and sustainability over time. Second, we aimed to assess whether different predictors are related to RTW at 6 or 12 months after injury with a multifactorial approach studying predictors in different categories (i.e. demographic factors, injury related factors, post-injury stressors, and occupational factors).

Table 1. Predictors for RTW in 4 categories

<table>
<thead>
<tr>
<th>Demographic factors</th>
<th>Injury-related factors</th>
<th>Post-injury stressors</th>
<th>Occupational factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Cause of injury</td>
<td>Posttraumatic complaints</td>
<td>Occupational category</td>
</tr>
<tr>
<td>Gender</td>
<td>Injury severity</td>
<td>Psychological status</td>
<td>Workplace and social support</td>
</tr>
<tr>
<td>Education</td>
<td>CT-scan results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td>Concurrent symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extra-cranial injuries</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

METHODS

Design and setting

This study was part of a longitudinal multicenter cohort study (UPFRONT-study) on mTBI in three level-I trauma centers. Between 2013 and 2015, all patients with mTBI admitted to the Emergency Department (ED) were approached for participation in the UPFRONT study. MTBI was defined as an injury to the head resulting in a Glasgow Coma Scale (GCS) score of 13-15 and/or loss of consciousness <30min. Exclusion criteria were: previous TBI or psychiatric disease requiring hospital admission, inability for follow-up, and substance abuse.

Demographic variables and injury characteristics were obtained from medical records and Abbreviated Injury Scales were documented based on these records.²¹ For the assessment of extra-cranial injuries, ISS scores were calculated with the exclusion of AIS Head. On admission GCS scores and presence of posttraumatic amnesia (PTA) and loss of consciousness (LOC) were obtained. CT-scans were assessed and scored using the Marshall criteria by a board certified radiologist.²² For analyses, a dichotomization of
CT-scan results was applied (Marshall score of 1 = no abnormalities, Marshall score of 2-6 = CT-abnormalities). All patients included in the UPFRONT-study received questionnaires 2 weeks, 3, 6 and 12 months after injury.

For the current study, only patients in the working age range in the Netherlands (from 18-65), who were employed at time of injury and completed at least one outcome measurement (at 6 or 12 months) were selected.

**Measures**

*Return to work.* Return to work (RTW) was scored in three categories: 0= pre-injury work not resumed (no RTW (nRTW)); 1= pre-injury work resumed on a lower level, or less amount of hours (partial RTW (pRTW)); 2= complete work resumption in the same capacity compared to pre-injury (complete RTW (cRTW)). For logistic regression analyses, groups were dichotomized into no/partial RTW and complete RTW.

*Occupational factors.* Information on workplace in terms of occupational category, workload in hours/week, number of employees at this employer, and number of years patients had worked for this employer were obtained by questionnaires. Occupational categories were clustered in three levels: professional/managerial (e.g. executive, managerial function), skilled (e.g. sales, administrative support, repair), or manual labor (e.g. machine operators, private household, material moving), as also applied by Walker et al.5

*Posttraumatic complaints.* The Head Injury Symptom Checklist (HISC)15,23 was derived from the Rivermead Post-concussion Questionnaire (RPQ),24 and consists of 21 common PTCs such as headache, concentration problems, fatigue, and dizziness. Patients were asked to score complaints on a pre-injury and current level with values ranging from 0 to 2. Pre-injury scores were subtracted from current levels to create corrected scores. For analysis, corrected sum scores were calculated with a range from 0-21.

*Depression and anxiety.* The Hospital Anxiety and Depression Scale (HADS) was used to assess symptoms of anxiety and/or depression. The HADS is a 14-item questionnaire, with two subscales (HADS-A and HADS-D) of seven items each. Subscales are scored separately, with scores ranging from 0-21.25

*Post-traumatic stress.* For the assessment of posttraumatic stress, the Impact of Event Scale (IES) was applied.26 Fifteen statements are scored on a range from 0-5, resulting in a maximum score of 75. Eight items on the scale measure “avoidance” – staying away from reminders of the event, the other seven items concern “intrusion”- strong waves of emotion towards the event. For analyses, the total sum score was calculated.
**Statistical analyses**

Differences between the three groups (nRTW, pRTW and cRTW) were tested using parametric and non-parametric testing when appropriate. Post-hoc analyses to assess group differences were performed, using Bonferroni corrections. Logistic regression analyses were performed to predict return to work 6 and 12 months after injury (nRTW and pRTW vs. cRTW). Variables were included based on hypotheses according to existing literature, and selected using step-down variable selection, including all main effects and the interactions of education with occupational factors and ISS scores with occupational factors, with Akaike’s information criterion as stopping rule. In the regression analyses, for the predictor workload in hours/week, the nonlinear relationship with outcome could be approximated well with a restricted cubic spline with 3 knots.

Relationships between predictors and outcome of the resulting models were assessed with odds ratios (ORs) and graphical summaries. For continuous predictors, the ORs were scaled to correspond to a change from the 25th to the 75th percentile to facilitate interpretation. Subsequently, ROC-analyses were performed on both the 6-month and 12-month prediction model to calculate the area under the curve (AUC). We estimated the optimism by internal validation using 500 bootstrap samples. Logistic regression was performed in R version 3.3.2, with the *rms* package. Missing values of predictors were imputed with single imputation using *areImpute* function of the *Hmisc* package.

**RESULTS**

As illustrated in figure 1, of all patients included in the UPFRONT-study (n=1151), 81% was aged between 18-65 (n=928). Of those, 458 patients reported to have been employed at the time of injury. Patients with at least one outcome measurement (at 6 or 12 months after injury), were included resulting in 319 cases for analyses.

**Return to work**

Figure 2 represents a flow schedule of work resumption throughout the study. The number of patients shifting from category is presented below the figure. Throughout the year, an increasing number of patients completely returned to work. A shift of patient between all categories was present, also 6 months after injury.
**Figure 1.** Flow schedule of included patients.

**Figure 2.** Flow schedule of work resumption.

| Positive change in RTW status (up sloping arrows) | 117 | 47 | 41 |
| Negative change in RTW status (down sloping arrows) | 3  | 8  | 10 |

X-axis represents 4 measurement moments. The percentage of patients in three categories is represented by bars (y-axis, complete, partial or no work resumption). Arrows represent patient flow, with the thickness of the arrow corresponding with number of patients (the thicker the arrow, the more patients). Horizontal arrows represent patients that stay in the same category, whereas up- or down sloping arrows represent a shift in category. # Values represent number of patients.
In Figure 3 the mean number of posttraumatic complaints from 2 weeks – 12 months is depicted separately for nRTW, pRTW, and cRTW patients. At each time interval, significant differences were present between cRTW and pRTW and between cRTW and nRTW (all p-values < 0.001). No significant differences were present between pRTW and nRTW.

**Figure 3.** Posttraumatic complaints for all levels of work resumption through the first year after injury. SEM: Standard error of the mean.

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**Group differences**

Six months after injury, 213 patients (67%) completely returned to work; 53 patients (17%) worked on a lower level or less amount of hours, and 50 patients (16%) did not return to work. In Table 2, groups are compared on demographic, injury, post-injury and occupational factors. Overall, nRTW patients were more severely injured (as indicated by GCS and ISS) and had more posttraumatic stressors two weeks after injury (complaints, anxiety, and depression) when compared to pRTW and cRTW patients.
### Table 2. Patient characteristics of three RTW categories at 6 months post-injury.

<table>
<thead>
<tr>
<th></th>
<th>1= nRTW n=50</th>
<th>2= pRTW n=53</th>
<th>3= cRTW n=213</th>
<th>Difference 1-2-3</th>
<th>Statistic (df)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, years, mean (SD)</td>
<td>49.1 (11.0)</td>
<td>44.6 (13.8)</td>
<td>44.7 (12.1)</td>
<td>F= 2.72 (2)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Male gender</td>
<td>66</td>
<td>47</td>
<td>69</td>
<td>X2= 9.18 (2)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Education, median (range)</td>
<td>5 (2.7)</td>
<td>5 (2.7)</td>
<td>5 (2.7)</td>
<td>H= 4.76 (2)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Partnered</td>
<td>90</td>
<td>69</td>
<td>70</td>
<td>X2= 2.47 (2)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td><strong>Injury-related factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVA (yes)</td>
<td>40</td>
<td>30</td>
<td>12</td>
<td>X2= 27.43</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>ISS score, mean (SD)</td>
<td>12.2 (9.0)</td>
<td>9.8 (6.3)</td>
<td>6.7 (4.4)</td>
<td>F= 16.94 (2)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>CT-abnormalities</td>
<td>23</td>
<td>25</td>
<td>12</td>
<td>X2= 13.94 (2)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Nausea or vomiting at ED</td>
<td>28</td>
<td>36</td>
<td>32</td>
<td>X2= 0.74 (2)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Alcohol usage day of injury</td>
<td>39</td>
<td>13</td>
<td>35</td>
<td>X2= 10.48 (2)</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>GCS score</td>
<td>14.3 (0.8)</td>
<td>14.4 (0.6)</td>
<td>14.6 (0.6)</td>
<td>H= 10.33 (2)</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>Posttraumatic amnesia</td>
<td>84</td>
<td>90</td>
<td>89</td>
<td>X2= 0.89</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>80</td>
<td>85</td>
<td>82</td>
<td>X2= 0.37</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td><strong>Occupational factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workload hours/week, mean (SD)</td>
<td>33.2 (12.2)</td>
<td>32.8 (8.1)</td>
<td>34.3 (11.5)</td>
<td>F= 2.231 (2)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Occupational category</td>
<td></td>
<td></td>
<td></td>
<td>H=12.724</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Professional/managerial</td>
<td>22</td>
<td>46</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skilled</td>
<td>49</td>
<td>48</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual labor</td>
<td>29</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post-injury personal factors (2 weeks after injury)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTC, mean (SD)</td>
<td>8.3 (5.0)</td>
<td>8.6 (4.1)</td>
<td>5.1 (4.2)</td>
<td>F= 19.92 (2)</td>
<td>P&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>HADS Anxiety, mean (SD)</td>
<td>5.5 (4.5)</td>
<td>4.6 (3.7)</td>
<td>3.7 (3.3)</td>
<td>F= 5.04</td>
<td>p=0.007</td>
<td></td>
</tr>
<tr>
<td>HADS Depression, mean (SD)</td>
<td>6.6 (5.4)</td>
<td>5.2 (3.4)</td>
<td>2.8 (3.3)</td>
<td>F= 21.44</td>
<td>p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Posttraumatic stress, mean (SD)</td>
<td>20.8 (16.0)</td>
<td>13.4 (12.5)</td>
<td>12.9 (12.6)</td>
<td>F= 6.25</td>
<td>p=0.002</td>
<td></td>
</tr>
</tbody>
</table>

All numbers are indicated as percentages, unless indicated otherwise.
Predictors
For logistic regression analyses, RTW groups were dichotomized into complete vs. partial and no RTW, all variables displayed in table 2 were added to the analyses. Table 3 shows odds ratios (OR, with 95% CI) of the predictors in the final models for 6 month and 12 month RTW. Regarding the model for predicting 6 month RTW, three demographic variables (age, gender and education) and three injury related factors (being involved in an MVA, ISS score excluding head, and GCS score) were predictive for RTW. Furthermore, workload in hours/week and occupational category were of influence, with a non-linear effect of workload in hours/week and an interaction effect of education with occupational category (figures 4 and 5). However, there were only few manual laborers within the highest education group and few patients with professional/managerial function within the lowest education group. The number of PTC and score on HADS-D were also associated with lower odds of RTW. The area under the curve (AUC) of the final model was 0.82 in the sample with 0.02 optimism.

Table 3. Logistic regression analyses for 6 and 12 month RTW

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coding</th>
<th>Odds ratios (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6 month RTW</td>
</tr>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>56:36</td>
<td>0.59 (0.33-1.04)</td>
</tr>
<tr>
<td>Gender</td>
<td>Female:Male</td>
<td>0.45 (0.20-1.00)</td>
</tr>
<tr>
<td>Education (Verhage)</td>
<td>5:4</td>
<td>1.37 (0.69 – 2.72)</td>
</tr>
<tr>
<td><strong>Injury characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVA (0=no)</td>
<td>Yes:no</td>
<td>0.17 (0.07-0.40)</td>
</tr>
<tr>
<td>ISS excl head</td>
<td>5:0</td>
<td>0.36 (0.20 – 0.65)</td>
</tr>
<tr>
<td>GCS score</td>
<td>15:13</td>
<td>2.56 (0.96-6.88)</td>
</tr>
<tr>
<td><strong>Occupational factors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupational category</td>
<td>Professional:skilled</td>
<td>0.38 (0.15-0.98)</td>
</tr>
<tr>
<td></td>
<td>Manual:skilled</td>
<td>0.38 (0.12 -1.17)</td>
</tr>
<tr>
<td>Workload in hours/week</td>
<td>40:28</td>
<td>1.25 (0.71 – 2.20)</td>
</tr>
<tr>
<td><strong>Two weeks after injury</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HISC # of complaints</td>
<td>9:2</td>
<td>0.44 (0.24-0.83)</td>
</tr>
<tr>
<td>HADS depression</td>
<td>5:1</td>
<td>0.56 (0.38-0.83)</td>
</tr>
</tbody>
</table>
Return to work after mTBI

**Figure 4.** Nonlinear effect of workload in hours/week for prediction of RTW at 6 months.

![Nonlinear effect of workload in hours/week](image)

**Figure 5.** Interaction effect of education and occupational category prediction of RTW at 6 months.

![Interaction effect of education and occupational category](image)

At 12 months after injury, 77% completely returned to work. Predictors for incomplete long-term work resumption were extra-cranial injuries as defined by ISS, and the HADS-depression score and the number of PTC on the HISC after 2 weeks resulting in a prediction model with an AUC of 0.81 in the sample, with 0.01 optimism.
DISCUSSION

The aims of this study on return to work after mTBI were twofold. First, we set out to explore the pathway of patient flow regarding levels of work resumption the first year after injury. We found that the percentage of patients that completely resumed their vocational activities (cRTW) increased from 34% at 2 weeks to 84% at 12 months after injury. The group of patients with partial work resumption (pRTW) was substantial, varying from 8-16% throughout the year. Interestingly, patients shifted between all categories of work resumption, even after six months, indicating that improvement or decline of functioning may take place at any time during the first year after injury. Second, we focused on finding predictors for 6 and 12-month work resumption, taking into account occupational factors such as workload in hours per week and occupational category. Apart from previously identified predictors such as the presence of extra-cranial injuries, age, education, cause and severity of injury, and indicators of psychological distress, occupational factors were found to be of influence for work resumption after six months, while at twelve months the model was solely based on the presence of extra-cranial injuries, and indicators of psychological distress early after injury.

Most studies report RTW as the first day back to work, but abstain from mentioning whether patients resumed work at the same capacity. Therefore, in the current study we measured and reported RTW in three levels, thereby showing that several steps may be involved before complete RTW, and that around 10% of patients work at a partial level at 12 months after injury. Including these pRTW patients in cRTW or in nRTW figures is an inadequate representation of RTW rates after mTBI. The few studies that did describe pRTW patients as a separate group, showed frequencies around 20%, comparable to our findings. When comparing the three patient groups, we demonstrated that pRTW patients are in fact not always comparable to nRTW or cRTW patients, indicating they represent a separate subgroup and should deserve further scientific attention.

One of the major findings of this current study pertains to the issue of work sustainability: the shift in levels of RTW throughout the year. To our knowledge, this study is the first to describe patient flow over levels of work resumption throughout the first year after mTBI. Most patients shift to a “better” category (i.e. from nRTW to pRTW to cRTW), however at each measurement moment, some patients shift to a lower level of work. Job stability after mTBI is a sparsely researched subject. Most studies that addressed work sustainability investigate groups with various injury severities (i.e. ranging from mild-severe), limiting the possibility to draw conclusions regarding mTBI patients only. From the current study we can conclude that not only for patients with moderate and severe TBI but also for mild TBI, problems may arise after the first day back to work. In other words, return to work
Return to work after mTBI does not necessarily mean that patients stay at work or have resumed work on pre-injury levels. Important questions that remain to be studied are whether these patients can be identified in an earlier stage, to prevent problems in the chronic phase. An interesting method to approach this last question is to create groups based on stability of work. In several studies on job stability, occupational factors have been indicated as predictors for stable employment, thereby demonstrating the importance of including these factors in clinical studies.\textsuperscript{29,32}

With logistic regression analyses, we developed a prediction model for RTW 6 months after injury. Several predictors that we identified have been shown to be of influence on work resumption in previous studies, such as age,\textsuperscript{8} education,\textsuperscript{18} extra-cranial injuries,\textsuperscript{18} cause of injury,\textsuperscript{10} and psychological status.\textsuperscript{11,15} Furthermore, we found that women were less likely to return to work after six months when compared to men, an effect that has been subject to debate over the years.\textsuperscript{3,13} Contrarily, we found no effect of several previously described predictors such as relationship status, CT-scan results, concurrent symptoms (i.e. nausea and vomiting), and day of injury alcohol intoxication.\textsuperscript{18,33} However, we included several occupational factors that influenced the resulting prediction model.

First, we added to the knowledge on the role of pre-injury occupational categories in RTW. As already described by Walker and colleagues, being employed as a manual laborer was associated with the lowest odds of return to work.\textsuperscript{5} In our model, an interaction effect of education and occupational category was present. However, few manual laborers were educated on a high level, and few patients with managerial/professional function were lower educated, complicating extrapolation of results. Notwithstanding this limitation in our sample, we can support the hypothesis that occupational category is of influence of RTW. The second occupational factor we identified as a predictor in our model was workload in hours per week, which formed a non-linear U-shaped effect.

Apparently, working approximately 32 hours per week is related to the lowest odds of RTW. It could be argued that those working a fulltime job (40h/week in the Netherlands), or even working more hours, have the strongest link with their workplace, relating to stronger feelings of responsibility. On the other side are those working less than 25h per week, possibly an amount of hours in which work and rest are perfectly combined. In this regard, it is important to assess whether other non-work related activities such as family life or recreational activities are affected by return to work, since cognitive and physical reserves might become exhausted. The latter is especially important given the fact that extra-cranial injuries were also predictive for RTW. Although the precise mechanism of occupational category and workload remain unclear, we can conclude that they – together with demographics, measures of injury severity, and signs of psychological distress – play a role in the multifactorial process of RTW, and should be taken into account when studying RTW after mTBI.
Regarding the prediction model for RTW 12 months after injury, the majority of effects we identified in the 6-month model disappeared. The only significant predictors left were extra-cranial injuries as defined by the ISS and the number of complaints (HISC) and level of depression (HADS-D) at two weeks after injury. Having sustained extra-cranial injuries proved predictive in both the 6-month and the 12-month model, indicating an important role for physical problems in vocational reintegration. The exact nature of these injuries that influence RTW should be studied more thoroughly to investigate possible targets for interventions. Both pRTW and nRTW patients reported on average 7 post-traumatic complaints throughout the year, raising the question why patients in the latter group did not return to work, while those in the former group manage to work at some extent. Personality traits and psychological wellbeing have been indicated as important factors of adapting to complaints. Apparently, indicators for psychological distress that can be measured early after injury are substantial contributors to long-term RTW and are more important than factors as age, education and severity of brain injury. A recent study demonstrated that cognitive complaints one month after injury are predictive for RTW 4 year after injury. In the current study we demonstrated that the sum score of PTC after 2 weeks was predictive for 6-month and 12-month RTW, adding to the evidence that the factors that interfere with long-term work resumption can be identified already early after injury.

The results of the performed logistic regression clearly indicate that RTW after mTBI is a multifactorial process of which clinicians should be aware. Not only risk factors in patients demographic and injury characteristics should be signaled, but also – and maybe even more important – occupational factors and adaptive capacities.

Limitations
Although this study provided valuable contributions to the mTBI field, some limitations need to be addressed. First, we were not able to obtain RTW data from all patients included in the UPFRONT-study, and some of the patients included in the current RTW study were lost to follow-up between 6 and 12 months after injury, limiting the generalizability of results. Second, we did not report the exact reasoning for patients to work on for instance a lower level. Other factors, apart from the mTBI, might have caused the patient to work on a lower capacity. However, our cohort was prospectively followed and included a substantial amount of patients with RTW rates comparable to other studies, thereby indicating an adequate representation of the population. Third, we addressed the issue of levels of work resumption in the first part of this paper, however, for the prediction model we dichotomized RTW at 6 and 12 months. Although this approach facilitates the interpretation and applicability in clinical practice, a multinominal analysis with a larger study sample might be a better fit, especially since we identified several differences between pRTW and nRTW patients. Lastly, the long-term RTW assessment took place 1
year after injury, which could be considered as still relatively short-term. Future studies should therefore focus on the role of occupational factors up to many years after injury, to facilitate personalized advises for patients in an early stage after injury.

CONCLUSIONS

This study on return to work provides valuable information on vocational rehabilitation after mild traumatic brain injury. We showed that a shift through categories took place throughout the year, and that patients resume activities even though they experience posttraumatic complaints. These complaints, and the presence of signs of psychological distress already early after injury may help in predicting which patients will encounter problems with short and long-term RTW. Last, we added to the evidence that occupational factors should be taken into account when advising patients on their work resumption and urge for more awareness of occupational factors among clinicians and researchers.
REFERENCES


